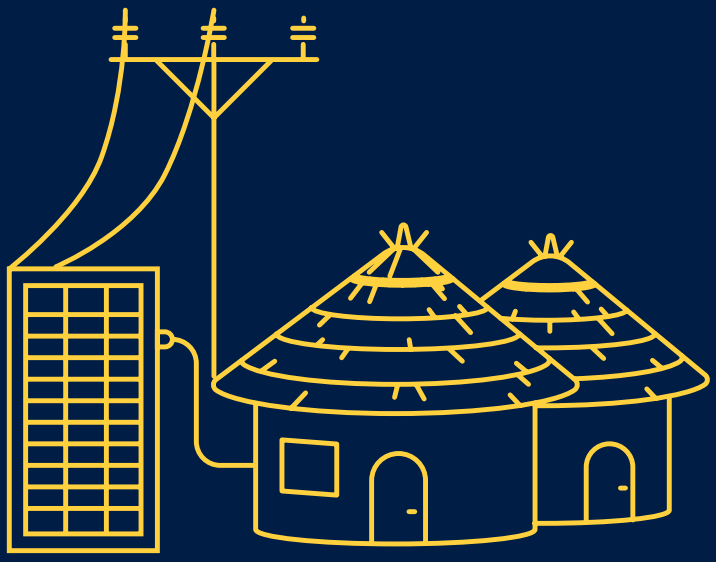
UNLOCKING AFRICA'S MINI-GRID MARKET
FINAL REPORT

USAID SCALING UP RENEWABLE ENERGY PROGRAM (SURE)

FEBRUARY 2021



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ACRONYMS

AMDA	African Mini-grid Developers Association
ARPU	Average Revenue Per User
AU	African Union
AUC	African Union Commission
AUC/DIE	Department of Infrastructure and Energy
CAPEX	Capital Expenditure
CBEA	CrossBoundary Energy Access
CBO	Community Based Organization
DFI	Development Finance Institution
ERB	Energy Regulation Board (Zambia)
ESCO	Electricity Supply Company
EUC	European Commission
GFP	Gender Focal Point
GMG	Green Mini Grid
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
IRENA	International Renewable Energy Association
KNES	Kenya National Electrification Strategy
kW	Kilowatt
kWh	Kilowatt Hour
LCOE	Levelized Cost of Electricity
MEL	Monitoring, Evaluation and Learning
MG	Mini-grid
MoE	Ministry of Energy
MSME	Micro, Small and Medium Enterprises
MW	Megawatt
NGO	Non-government Organization
ONE	Office National d'Électricité
OPEX	Operating Expenditure
PAYGO	Pay As You Go
POS	Point of Supply
PPA	Power Purchase Agreement
RBF	Results-based Financing
REA	Rural Electrification Agency
REF	Rural Electrification Fund
REG	Rwanda Energy Group
SDG	Sustainable Development Goal
SE4All	Sustainable Energy for All
SHS	Solar Home System
SPD	Small Power Distributor
SPP	Small Power Project/Producer
SPV	Special-purpose Vehicle
SURE	Scaling Up Renewable Energy
TBS	Tanzania Bureau of Standards
USAID	United States Agency for International Development
VRE	Variable Renewable Energy
ZEMA	Zambia's Environmental Management Agency

EXECUTIVE SUMMARY

PROJECT PURPOSE AND OBJECTIVES

The development of infrastructure in Africa is an integral part of the African Union (AU) Agenda 2063. The Agenda aims to achieve inclusive socio-economic development, which requires adequate electricity infrastructure at the continental, regional, national and local levels, including rural areas. Electricity is a prerequisite for economic development, and it improves social infrastructure such as health, education and financial services.

Sixty percent of Africans live in rural areas, only about 5% of which have access to modern electricity services. The lack of service is primarily caused by sparse settlements, low economic activity, distance to an existing grid and low population density.

African policies have focused on expanding grids in rural, peri-urban, and urban areas, with an emphasis on increasing national electricity grid coverage. As renewable energy generation technologies have become more affordable and efficient, mini-grids offer a viable alternative to grid expansion. They can bring electricity to millions living in rural and remote settlements with concentrated inhabitants while standalone solar home systems can be used to target areas with dispersed habitats.

Private sector companies are increasingly investing in mini-grids in Africa's rural areas, bringing innovative technology and financing solutions, dynamic business operating tools, and energy demand stimulation to improve their revenues and grow local economies. However, mini-grids face more challenges than their larger national utility counterparts. Some of these barriers stem from imbalance in subsidy allocation, governments' mandate for tariff parity between off-grid and on-grid power consumers, and lack of a supportive regulatory environment for mini-grid project developers.

This "Unlocking Africa's Mini-Grid Market" study was funded by Power Africa, through USAID's Scaling Up Renewable Energy (SURE) project. It will build on the

Countries define mini-grids differently in their policies, strategies and regulatory frameworks, as illustrated within this report. For the purpose of this analysis, we use the following definition: A mini-grid is any electricity supply system with generating capacity ranging from 1 kW to 10 MW (IRENA, 2016b) and can operate in isolation from the utility network's main grid. It comprises at least a power generation unit and a local distribution network and supplies electricity to more than one consumer. A micro-grid is 1 to 20 kW and is incorporated within the definition of a mini-grid.

mini-grid work of the African Union Commission / Department of Infrastructure and Energy (AUC/DIE) and the European Commission (EC). The study's objective is to complement the AUC/DIE work by developing guidelines for policymakers and regulators around five key themes: 1) off-grid policy, strategy and regulatory framework (also covering licensing and service territory allocation), 2) mini-grids business and financing models, 3) mini-grids interconnection terms, 4) mini-grids compensation mechanisms, and 5) mini-grids gender inclusivity.

This report assesses the current mini-grid policies, regulations and implementation strategies of ten countries across Africa (Democratic Republic of Congo, Ethiopia, Kenya, Morocco, Nigeria, Rwanda, Senegal, Tanzania, Tunisia and Zambia), as well as Cambodia and India. It examines their challenges, implementation successes and failures, and lessons learned.

The information provided by the AUC on mini-grids will help AU member states create an enabling environment for private sector engagement for the deployment and implementation of mini-grids to improve electricity access and rural productivity.

SCOPE OF THE STUDY

This study covers six tasks/thematic areas:

1. **Off-grid Policy and Strategy and Licensing Off-Grid Policy and Strategy and Licensing and MG Service Territory Allocation:** Many countries lack a rural electrification plan/strategy that includes specific targets for mini-grid deployment and detailed data to identify the electrification needs to inform the location of mini-grid sites. This study analyzes the process for allocating mini-grid service territories, obtaining licensing or authorization for mini-grids, licensing processes, and mini-grid territories versus national grid extension plans. It also provides lessons learned and guidelines on mini-grid licensing that integrate best practices.
2. **Business/Financing Models:** Research shows that mini-grid projects are often not economically viable without government subsidies. However, the sustainability and effectiveness of existing subsidy designs present an ongoing challenge for governments and the private sector. This study assesses business and financing models for mini-grid infrastructure development and highlights the success factors.
3. **Mini-grid Interconnection Terms:** This study describes existing technical and regulatory options for interconnection when the national grid reaches a mini-grid service territory. It provides guidelines on the terms to be applied when interconnecting the national grid and a mini-grid. Included in mini-grid regulations, the interconnection terms provide clarity to mini-grid developers and guide their investment strategy, including the choice of equipment type and the business model to be employed.
4. **Compensation Mechanisms:** Private companies in the mini-grid sector experience uncertainty over how they will be compensated when the national grid is expanded into their service territory before they have recouped their investment. This study examines case studies on the mechanisms and methodologies used in the 10 countries to articulate the principle considerations for compensation and guidelines for national mini-grid regulations. Compensation is one of the risks raised by investors and must be scrutinized during the due diligence of mini-grid projects.
5. **Gender Inclusivity:** Although men remain overrepresented in the power sector, women make important contributions in management and technical positions, including through work at leading mini-grid companies in the countries examined in this report. Especially in rural areas, women are the main beneficiaries of electrification access, which reduces time spent on housework and frees up time for education and income generating activities. This study explores best gender practices relevant to the mini-grid space.
6. **Tariff Calculation:** While tariffs are the core revenue generating stream for mini-grids, developers often face uncertainty because tariff regulations do not clearly guarantee cost recovery. In addition, without clear regulatory frameworks, customers are not protected and are vulnerable to high electricity tariffs. This study, conducted by the National Association of Regulatory Utility Commissioners (NARUC), inventoried tariff tools, developed an analysis report and gathered available users' manuals for publication on the AUC website. The Tariff Tools task does not follow the guidelines format below but will be provided in a separate report.

KEY FINDINGS ON MINI-GRID DEPLOYMENT ACROSS AFRICA

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This section summarizes the general observations and trends on mini-grid policies and regulations for the 12 countries analyzed in this study.

1. OFF-GRID POLICY AND STRATEGY AND LICENSING OFF-GRID POLICY AND STRATEGY AND LICENSING AND MINI-GRID SERVICE TERRITORY ALLOCATION

TRENDS

- Generally, the process for obtaining a mini-grid license is described in legislation. The required information and the site allocation (first come first served/unsolicited/concession) are indicated in the licensing regime. The legislation applies to both private and public-led models.
- Small capacity installations tend to be exempted from licensing but must still be registered.
- In almost all reference and case study countries, license conditions require adherence to national technical and service standards and prescribe the tariff and allocation of the service territory. A buy-out clause is also included for anticipated grid encroachment.
- Both solicited and unsolicited approaches should be considered in mini-grid site allocation with the choice made in accordance with the criteria set, nature and level of demand, etc.
- A first come first served approach is prevalent in countries that are trying to attract both foreign and domestic investment.
- Capacity building along the entire value chain is necessary to ensure systems' sustainability
- Technology choice should be flexible to ensure a least cost approach among other factors.

SUMMARY GUIDELINES

Off-Grid Policy and Implementation Strategy

- Energy policy and rural electrification strategies should be flexible enough to find least cost rural electrification solutions including mini-grids and other off-grid electrification technologies.
- The government's institutional set-up should be structured to include clear oversight of off-grid initiatives to ensure systematic implementation.
- Capacity building should be strengthened along the entire value chain to enable effective implementation and sustainability.
- Rural electrification targets should be set, and performance monitored.
- Technological reviews should be undertaken carefully and systematically.
- Enabling investment environment (including incentives) should be enhanced and well elaborated to encourage strong and effective private sector engagement in this subsector.
- Stakeholder engagement with beneficiary communities, the private sector, civil society, academia, etc. should be conducted.
- Investment barriers – including capital requirements, tariffs, and subsidy requirements – should be examined to ensure the effective implementation of rural electrification strategies to include mini-grids.
- Different financing mechanisms and investment models should be assessed to inform decision-making.

Legal and Regulatory Framework

- It is important that the legal and regulatory framework is transparent, and that the regulations' requirements and obligations are enforced. This pertains to licensing for power generation and/or distribution and trading, economic regulation, obligations related to the utilities and other energy service providers.
- Regulatory frameworks need to include electricity pricing and describe the allowed business models and permitting procedures. It is important that regulations provide for a mini-grid license/permit that covers generation, distribution and sales of electricity to end-users.
- Simplified regulations for very small size projects can speed their deployment.
- There should be a legal framework that provides for a situation when the grid encroaches the MG service territory.
- It is important to have a legal and regulatory guidance on provision of incentives and subsidies.
- Streamlining licensing and permitting processes to minimize authorizing entities is key in facilitating investors.
- Developers need to be transparent (to the regulator) about their investment and financing sources and tariff calculation. This is important in protecting the end user consumers from tariff gouging.
- It is important that regulations state the threshold capacity above which the retail tariff must be regulated.

Licensing and Service Territory Allocation

- Site allocation/reservation approaches should be open to both solicited and unsolicited options following the criteria set forth including the nature and level of demand.
- A time-limited provisional license/registration/permit for site reservation or allocation should allow developers to carry out feasibility studies and seek funding for construction, but at the same time protects communities from being taken advantage of by developers.
- A concession agreement providing for occupation of the location and duration of the concession should be entered upon commissioning of the mini-grid and start of operations.

2. BUSINESS/FINANCING MODELS

TRENDS

- Business models are still evolving and there is ongoing experimentation to determine optimal mini-grid business models. The following areas are driving the development of viable commercial mini-grid business models:
  - Affordable tariffs that optimize average revenues per customer.
  - Increasing productive use of electricity.
  - Service quality and reliability of mini-grids as a source of competitive advantage over the main grid and solar home systems.
  - The off-grid power purchase agreement (PPA) is another promising business model but requires a fund at the beginning to absorb the difference between the feed-in tariff and the bulk tariff.
  - Innovative project finance that allows investors and lenders to provide long-term financing based on the cash flow generated by the mini-grid's assets. There is interdependency among business models, financing models and the regulatory regime. A commercially viable business model with certainty in revenue streams can unlock additional funding sources from long-term debt capital/project finance. The regulatory regime is important to providing the revenue certainty from tariffs.

Results-based financing (RBF) —a per connection or per kWh subsidy— paid to the mini-grid developer is vital to increasing universal access. Private investors favor RBF because governments and donors match private capital to de-risk mini-grid deployments. As private off-grid companies deploy new technologies and business models, the RBF subsidy is expected to decline over time as the economics of rural electrification improve and off-grid technology costs decrease with scale.


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SUMMARY GUIDELINES

Business Models

- Policy and regulations should allow an ownership model that protects property rights. Those property rights should be reflected in provisions for willing-buyer-willing-seller with commensurate compensation (i.e., should not be confiscatory) and based on best practices in the mini-grid sector.
- Policy and regulations should be flexible on operating models but issue hard coded operating standards, service reliability and safety standards among other mini-grid performance obligations.
- Regulators have an important role in setting the right tariff, which is an important business model success factor for a mini-grid developer – There is a delicate balance between customer needs, developer economics, and the socioeconomic requirements of the policymaker.
- Policy makers should support education of consumers on usage of electricity to stimulate electricity demand to catalyse maximize social benefit of mini-grid service areas and increase mini-grid revenue and sustainability.
- Policy and regulations should be flexible to embrace new business models as they evolve.
- Regulation should facilitate mini-grid operational sustainability.

Subsidies and Government incentives

- Mini-grids, like all prior rural electrification programs, will require government incentives and subsidies from other sources for capital and operating expenditure (CAPEX and OPEX).
- Subsidies and government incentives should be accessible to both public and private sector entities delivering rural electrification (grid expansion or mini-grid).
- Subsidies and government incentives extended to the private sector should be awarded via a competitive (tender and/or auction) process in line with the country's public procurement regulations to ensure transparency and value for money to the public.
- There should be clear accountability and independent results verifications of the outcomes of the subsidies and government incentives for them to be accessed by the private sector
- The subsidies and government incentives should be targeted, reduce over time and be time-limited with an endpoint, upon which they are to be replaced by electricity productive uses and social enterprises that can lift the communities out of poverty.
- Government incentives should not be about government paying private sector, but about equity, to treat all sources of energy systems the same (i.e., energy technology neutrality in incentive dispersal)

Financing Models

- Government policy and regulations on tariffs that ensure cost recovery are key to unlocking other sources of funding, especially debt and project financing that will give mini-grids access to required long term financing.
- Adjust regulatory frameworks to embrace new funding initiatives like guarantees and blended finance to unlock capital for the mini-grid sector. The regulatory framework could evolve to support the economics of these new financing models

3. INTERCONNECTION TERMS

TRENDS

- There are many issues that policymakers, regulators and utilities have to address when creating favorable mini-grid interconnection regulations. The grid codes of most countries are designed around the compliance of large-scale utility power plants interconnecting with the grid at a point of supply where a utility company meters electricity that the power producer sells. However, mini-grids are much smaller and often distribute power to customers behind their point of supply. The smaller scale of mini-grids and the low consumption of their customers can make it unprofitable for private mini-grid developers and operators to comply with current grid code requirements. Important findings from the case study countries and literature include:
  - Minimize country-specific standards compliance cost through the adaption of regional or international standards, like the Institute of Electrical and Electronics Engineers (IEEE) 1547, into the grid code.
  - Allow mini-grids to intentionally island (i.e., temporarily disconnect from the grid and operate independently), provided they follow recognized standards, for example IEEE 1547.4-2011.
  - Create a tiered structure for grid code compliance that allows small-scale mini-grids to meet fewer interconnection regulations than large-scale utility power plants.
  - Design a streamlined interconnection application process with minimal approving authorities; harmonize the application of rules across approving authorities; and ensure both the applicants and approving authorities have deadlines for completing tasks. Smaller mini-grids should be able to complete the application process faster than larger mini-grids.
  - Standardize the costs for processing an interconnection application (e.g., utility administration costs associated with engineering inspections and document handling) and make them transparent and as low as possible. In general, applicants are responsible for hardware, labor and testing for commissioning up to their point of supply. The option should exist for applicants to pay for grid studies, hardware upgrades and utility supervision beyond the point of supply should they wish to avoid potential delays.

SUMMARY GUIDELINES

Mini-grid Interconnection Terms

- Larger mini-grids should be compatible with the grid, but requirements should vary with mini-grid size.
- Regulations should be based on national or regional standards that minimize country-specific compliance costs for mini-grid developers and operators.
- Intentional islanding of a mini-grid should be allowable if international standards are followed.
- The application approval process for interconnection should be straightforward and appropriate.
- Ensure interconnection application costs and duration are predictable for the applicant.
- A process should be in place to resolve disputes between the utility and applicant.
- Grid stability analyses should be required as part of the interconnection application process for applicant with variable renewable energy generation.

4. COMPENSATION MECHANISMS

TRENDS

- The prospect that the national grid can extend into a mini-grid service area has always introduced an element of uncertainty in private investors' ability to realize a return on their off-grid investment. Some country governments are trying to devise different mechanisms and approaches to ensure investments are not discouraged. Mini-grid permits and licenses should provide adequate legal protection for private investors and enable mini-grid owners to seek compensation for the cost of privately financed assets and any lost revenues when a mini-grid encroaches on their service area. Governments should also provide guidance on how the mini-grids might eventually be integrated into the national grid.
  - Most study countries have regulations either in place or in draft form that provide for compensation; however, India and the DRC do not. In Senegal, regulations provide for the transfer of assets, compensation is not mandatory, and no methodology is described for determining the compensation amount. It is hoped that the regulations currently under development will plug this gap.
  - While several countries' compensation policies are described in regulations, they have not been applied in practice. The Africa Mini-grids Developers Association (AMDA) stated that the "compensation topic is much less important than what people think, mini-grids go to areas where the grid is not anticipated to arrive that soon; mini-grids are likely to work closely with the utility and even in parallel, like the case of Powerhive in Kenya which provides power service almost 'under the Kenya Power and Lighting Company (KPLC) grid.'"[1] Still, it is important for regulations to provide for compensation and specify a valuation model that is reasonable.

[1] "Under the grid" is an expression that describes communities who live within the distribution company service area, but receive unreliable, intermittent and/or low-quality power.

SUMMARY GUIDELINES

Compensation Mechanisms

- It is important that mini-grid regulations address the anticipated encroachment of the main grid into the mini-grid service territory. The regulations should:
  - Provide guidance on models of how the mini-grids might eventually be integrated into the national grid.
  - Provide for certainty in compensation as appropriate.
  - Specify the eligibility criteria for such a compensation.
  - Specify a credible valuation model for determining amounts eligible for compensation.
- Several compensation models can be considered based on best practices and the models for integration of the mini grid into the national grid.
- It is important to know where the money will come from to pay the compensation.
  - There is a need to set aside a guarantee fund for compensation.
  - The buyout clause needs to be backed by that guarantee fund, and the fund would also provide insurance for foreign exchange and political risks.
- Regulators should require better communication on the expected grid expansion plans. Utilities should develop electrification plans that clearly define the on- and off-grid territories to comply with said regulation.

5. GENDER INCLUSIVITY

TRENDS

There are several commonalities across three countries examined: Zambia, Colombia and Rwanda.

- All have policies and strategies in place for gender mainstreaming in the energy sector but are at varying stages of developing and implementing specific actions and strategies to improve gender equality and women's empowerment. In addition, they have begun the process of embedding gender mainstreaming in mini-grid specific policies and strategies.
- Gender focal points (GFPs) are in place within ministries of energy, which are tasked with developing and implementing gender mainstreaming strategies and plans. There are varying levels of responsibility assigned to GFPs, and in some instances there is more accountability at top senior management levels to ensure the implementation of gender action plans.
- While there are varying stages of development of action plans in place to accompany gender policies in the energy sector, resources have not been allocated to implement planned actions.
- These countries are at the beginning stages of planning how to address gender mainstreaming related to mini-grids and renewables.
- There is increasing emphasis on the importance of gender-descriptive and sex-disaggregated data collection, gender analysis, and gender assessments as fundamental to formulating strong evidence-based gender mainstreamed policies and action plans.

SUMMARY GUIDELINES

Gender Inclusivity

- Energy policies, strategies, directives, and action plans should be updated by policy-makers to mainstream gender with concrete actions at the sector level, as well as within specific mini-grid policies and strategies, and should include policy and regulation enforcement tools, such as gender parity quotas. This should be informed by a gender analysis or assessment and should be accompanied by a gender mainstreamed monitoring, evaluation and learning (MEL) plan and budget, with gender expertise engaged for successful implementation.
- Action plans should be specific, strategic, and practical, and based on sound gender analysis. Two resources can be used to support this: NARUC Practical Guide to Women in Energy Regulation and USAID Energy Equality: the importance of integrating gender equality in national energy policies and frameworks.
- Government policies should require that mini-grid developers conduct project-specific gender analysis and inclusive, equitable community engagement during mini-grid feasibility to ensure developers meaningfully address gender equality in the design, service delivery, and workforce of all mini-grid developments, with an emphasis on empowering women to engage in income-generating activities throughout the entire supply chain.

6. ENVIRONMENTAL

SUMMARY GUIDELINES

Environmental and Social Impact of Mini-Grids

- It is important to consider environmental, health and safety (EHS) impacts of mini-grids in project design, implementation and monitoring.
- Risk mitigation measures should be designed to ensure project sustainability and regulatory compliance.
- For developers of small power projects, ESIA's are costly and complex. Therefore, governments should assist developers to fulfill this requirement by providing financial support. Alternatively, governments can undertake ESIAs in one area where the generating source is the same and covers several concessions. Developers can then be included in such ESIAs and not have to incur costs to complete them.
- Mini-grid systems should be built and installed by trained professionals and implemented in accordance with manufacturer requirements and best practices in electrical engineering. End users should be trained in the correct use of the equipment before using it so that they understand its limitations, proper usage and all relevant safety requirements. This is particularly important in areas that have limited experience with electricity.

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1. INTRODUCTION

1.1 BACKGROUND

To unlock access to basic infrastructure in rural and remote areas of Africa, the AU Agenda 2063 aims for a "prosperous Africa based on inclusive growth and sustainable development" with the objective of promoting social, economic, human and political development. The achievement of inclusive socioeconomic development and a transformation of African countries will require adequate energy infrastructure at all levels. This infrastructure will enable the provision of commodities and services that are essential to enable, sustain and enhance living conditions.

In Africa, rural areas are generally characterized by a lack of electricity services. Past policies have focused on grid expansion for the electrification of rural and urban areas, with an emphasis on increasing coverage by the national electricity grid. Sixty percent of Africa's population currently live in rural areas, but only about 5% of this rural population has access to modern electricity services. To address these shortcomings, the AU has begun to support better-coordinated initiatives.

Renewable energy generation technologies have become more affordable and efficient and can offer viable alternatives to providing electricity to millions of Africans living in rural and remote villages. Private sector companies are increasingly investing in the deployment of mini-grids in rural areas of Africa. They bring innovative technology, financing solutions, dynamic business operations tools, and energy demand stimulation to improve their revenues and grow local economies. However, these privately deployed mini-grids experience significant limitations compared to their larger national utility-built counterparts. Some of these limitations stem from an imbalance in subsidy allocation compared to national utilities, governments' mandate for tariff parity between off-grid and on-grid power consumers, and lack of a supportive regulatory environment for mini-grid project developers.

1.2 STUDY OBJECTIVES AND PURPOSE

GOAL

The overall objective of the Unlocking Africa's Mini-grid Market Study is to provide policymakers of AU member states with models for licensing, interconnection terms, compensation mechanisms for mini-grids, and business and financing models (including tariff approval mechanisms) and gender inclusivity actions that will support/enhance the mini-grid policies of African countries.

OBJECTIVES

- Critically examine existing mechanisms for compensating mini-grid developers across Africa and other parts of the world to ensure they can recoup their investments.
- Highlight key lessons learned as well as success factors of mini-grid projects. As part of this, articulate the principal considerations for compensation and develop guidelines for national mini-grid regulations.
- Conduct an assessment and determine an inventory of business models for mini-grid infrastructure development in Africa and across the world, including case studies under various business models, highlighting success factors that address:
  - The challenges faced by governments and donor agencies in supporting the capital investments needed for grid extension to rural consumers as well as cross-subsidies from urban consumers of the same utility.
  - The efficiency of CAPEX subsidies in regard to achieving universal access to electricity.
  - The challenges of results-based financing such as connection subsidies, the understanding of the PPA model to mini-grid projects, perception of the franchisee model, as well as resultant tariff handling mechanisms.
- Analyze existing min-grid tariff tools across Africa; compile available tariff calculation tools and upload them on the AUC website.
- Describe existing technical and regulatory options for interconnection when the national grid reaches a mini-grid service territory.
- Analyze options, highlighting best practices and lessons learned as well as identifying challenges faced by different options, and recommend ways of resolving them and outline the role of each stakeholder during the implementation phase.
- Develop guidelines on the interconnection terms to be applied when connecting a mini-grid to the national grid when the national grid reaches a mini-grid service territory.

1.3 SCOPE OF THE STUDY

The study covers the following six thematic areas/tasks.

1. **Off-grid Policy and Implementation Strategy, Legal and Regulatory Framework, Licensing and Service Territory Allocation:** Many countries lack a rural electrification plan/strategy that includes specific targets for mini-grid deployment and detailed data to identify the electrification needs to inform the location of mini-grid sites. This study analyzes the process for allocating mini-grid service territories, obtaining licensing or authorization for mini-grids, licensing processes, and mini-grid territories versus national grid extension plans. It also provides lessons learned and guidelines on mini-grid licensing that integrate best practices.

2. **Business/Financing Models**: Many discussions focus on whether cost-reflective tariffs or a uniform national tariff should be applied to off-grid mini-grid consumers. In several cases, rural electrification (whether through grid expansion or decentralized mini-grids) is not financially viable, so rural customers benefit from capital investment on grid expansion funded by government and donor agencies as well as cross-subsidies from urban consumers of the same utility. The challenges faced by both governments and the private sector include: how to channel subsidies to private micro-utilities; the sustainability of subsidies in general; the efficiency of CAPEX subsidies in terms of achieving universal access to electricity and results-based financing such as connection subsidies; understanding of the PPA model to mini-grids projects; and the perception of the franchisee model. This study provides a thorough assessment of the business models used for mini-grid infrastructure development in the case study and reference countries.
3. **Mini-grid Interconnection Terms:** This study describes existing technical and regulatory options for interconnection when the national grid reaches an area already served by a mini-grid. It analyzes different options and highlights best practices and lessons learned, and identifies challenges faced and recommends ways of resolving them, outlining the role of each stakeholder. Last, it provides guidelines on the interconnection terms to be applied when interconnecting the national grid and a mini-grid.
4. **Compensation Mechanisms:** Private companies in the mini-grid sector experience uncertainty over how they will be compensated when the national grid is expanded into their service territory before they have recouped their investment. This study examines the different valuation methodologies used by the case study and reference countries. The analysis includes case studies of successful and failed mini-grid projects to capture the key lessons learned and success factors. Thereafter, it articulates the principal considerations for compensation and guidelines for national mini-grid regulations.
5. **Gender Inclusivity:** Although men remain overrepresented in the power sector, women make important contributions in management and technical positions, including through work at leading mini-grid companies in the countries examined here. Especially in rural areas, women are the main beneficiaries of electrification access, which reduces time spent on housework and releases time for education and income generating activities. This study explores gender best gender practices relevant to the mini-grid space.
6. **Tariff Calculation:** While tariffs are the core revenue generating stream for mini-grids, developers often face uncertainty because tariff regulations do not clearly guarantee cost recovery. In addition, without clear regulatory frameworks, customers are not protected and are vulnerable to high electricity tariffs. This study conducted by the National Association of Regulatory Utility Commissioners (NARUC) inventoried tariff tools, developed an analysis report and gathered available users' manuals for publication on the AUC website. The Tariff Tools task does not follow the guidelines format below but will be provided in a separate report.

2. STUDY DESIGN, APPROACH AND METHODOLOGY


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The Unlocking Africa's Mini-Grid Market Study builds on the foundational work of the AUC-EU on mini-grids, consultations with stakeholders at an inception workshop held in March 2019 (see Section 3.2), and best practices from around the world. As part of the study, the team held in-country interviews with representatives of the case study countries using a questionnaire to ensure targeted and consistent information and conducted literature research on the reference countries. Together, the interviews and research shed light on the best practices, success factors, challenges and topical issues described in this report. They also informed the policy and regulatory guidelines presented here.

2.1 PREVIOUS FOUNDATIONAL WORK

The Unlocking Africa's Mini-Grid Market Study follows an initial AUC initiative (supported by the European Union Technical Assistance Facility for the Sustainable Energy for All (SE4ALL) initiative in Eastern and Southern Africa: Institutional and Policy Model for Micro-/Mini-Grids) that examined the question: What role should governments play in developing mini-grid policy and institutional guidelines? The initiative sought to develop guidelines as a first step in understanding the options and policy-level decisions required in designing a rural mini-grid electrification approach. It also provided relevant references for more detailed information. Its February 2017 final report was geared toward national- and regional-level policy makers, regulators, utilities and power off-takers, the private sector and technology developers. It described technological options pertaining to sources of energy, policy barriers to mini-grid deployment, mini-grid operating models in different parts of the world, mini-grid tariff models, private sector involvement in the expansion and sustainability of mini-grid development, and various subsidies to encourage mini-grid market growth and offset investor risk.

2.2 INCEPTION WORKSHOP

The first phase of this study developed an inception report based on a workshop held for energy experts from AU member states. The workshop presented a literature review on the various themes of this study and stakeholders were asked to comment on them. The feedback incorporated in this study includes the following:

- Add licensing and off-grid policy and strategy to the themes.
- Add gender inclusion to the themes.
- Select case study countries from AU's five geographic areas.
- Make policy and regulatory definitions more granular.
- Broaden the study key questions (see Appendix A-2).

2.3 CASE STUDY AND REFERENCE COUNTRIES

During the inception workshop, the SURE team worked with AUC/DIE to select countries that would provide a breadth of mini-grid compensation, interconnection, tariff, and subsidy policies and regulations to inform the project's guidelines (the case study countries). AUC/DIE stakeholders selected the countries using a scoring tool (see Appendix A-7). Using the same selection criteria, five reference countries were selected to illustrate global practices.

TABLE 2.1: CASE STUDY AND REFERENCE COUNTRIES

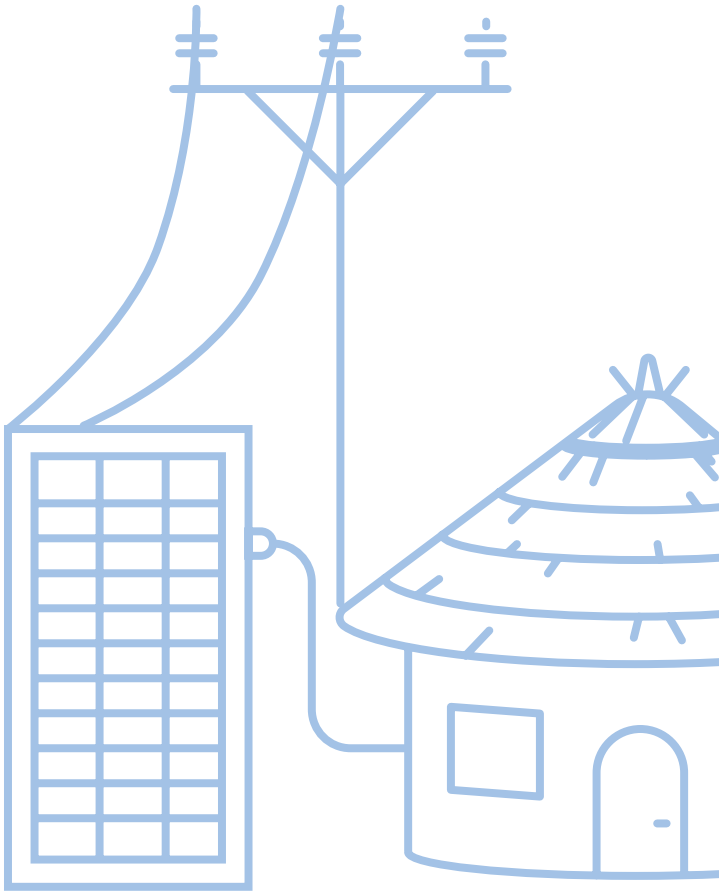
CASE STUDY AND REFERENCE COUNTRIES

CASE STUDY COUNTRIES	REFERENCE COUNTRIES
Rwanda, Senegal, Tanzania, Tunisia, Zambia	Cambodia, Democratic Republic of Congo, Ethiopia, India, Kenya, Morocco, Nigeria

See Appendix A-6 for case study countries' mini-grid and electrification statistics.

2.4 STAKEHOLDER INTERVIEWS

In-person interviews were held with key stakeholders in the case study countries. A questionnaire (see Appendix A.2) with a list of key questions for each theme was prepared to guide the respondents. The stakeholders interviewed were: mini-grids projects developers/promoters/investors, international donors, ministries of energy, rural electrification agencies, national or regional regulators, utility companies, and mini-grid owners and operators. To the extent possible, information was collected on individual micro-utilities, countries' policy and regulatory environments, and mini-grid project promoters/developers, which was critical to developing the practical guidelines provided in this report.



3. OFF-GRID POLICY, IMPLEMENTATION STRATEGY, REGULATORY FRAMEWORKS, LICENSING AND SERVICE TERRITORY ALLOCATION


Photo: © AdobeStock

This section begins with an overview of the roles of key stakeholders in the mini-grid market space. It then analyzes the challenges, current status and trends, success factors and failures, and lessons learned in three areas: 1) off-grid policy and strategy, 2) the legal and regulatory framework, and 3) licensing and service territory allocation. The discussion of each area concludes with a set of guidelines on policy and regulatory options for mini-grid policy-makers and regulators.

3.1 BACKGROUND ON STAKEHOLDER ROLES

Good governance practices help ensure effective and efficient mini-grid development. Developing and implementing good practices and strategies requires well-coordinated and supportive agencies and institutions (governmental and non-governmental, academic and other educational institutions). Among their roles are information management and public awareness, policy making and planning, training and organizational development, resource mobilization, and standards setting.

Institutional capacity is also key to the effective planning, design and implementation of mini-grids and other rural electrification initiatives. The capacity needs range from technical skills across the rural electrification value chain, including public and private institutions, to the financial institutions charged with lending as well as implementing rural electrification projects. Project preparation, including the transaction expertise needed to engage in negotiations for raising financing and engaging contractors for project implementation is crucial. Such skills gaps tend to impose more costs on the projects.

Table 3.1 describes the primary roles and responsibilities usually undertaken by each energy sector stakeholder to effectively implement national mini-grid strategies.

TABLE 3.1: KEY STAKEHOLDER MANDATES AND ROLES

KEY STAKEHOLDER MANDATES AND ROLES

THEME	GUIDELINES
Legislature/Parliament	• Enacts law pertaining to energy policy.
Ministry Responsible for Energy	• Formulates and administers national energy policy. • Designs rural electrification strategy and sets targets. • Defines and embraces operator models. • Plans and administers public resource allocations. • nitiates mini-grid institutional arrangements. • Builds the necessary capacity.
Treasury/Finance Ministry	• Provides rural electrification budget. • Avails and coordinates grant and concessionary loans for rural electrification. • Provides inputs on national electricity tariffs for the purposes of subsidy scheme determination. • Determines the stability of investment policy. • Designs and implements fiscal incentives.
Energy Regulator	• Facilitates and monitors the implementation of rural electrification targets, vision and mission. • Formulates and implements technical regulations (technical and service quality standards, main-grid interconnection requirements). • Formulates and implements economic regulations (tariffs, PPA, etc.). • Issues and monitors legal regulations (licensing, permit requirements). • Mediates disputes between users of the electrical system. • Provides advisories to other entities. • Formulates compensation mechanisms.
National Standards Bureau	• Provides general planning on tier standards requirements and approvals. • Sets standards on several mini-grids system requirements, including generation equipment, inverters, distribution lines, poles, aerial and underground cables, metering, interconnections, and others.
National Environment Authorities	• Ensures mini-grid meets national environment and health standards. • Issues environmental permits, as required. • Monitors compliance with environmental regulations.

KEY STAKEHOLDER MANDATES AND ROLES

THEME	GUIDELINES
Rural Electrification Agency (REA)	• Advises government on rural electrification strategy. • Implements rural electrification policy. • Develops rural electrification plans, including off-grid solutions. • Drives implementation of selected national operator models. • In some cases, performs specific regulatory tasks delegated to the REA. • Mobilizes rural electrification funding. • Organizes call for tenders/proposals for mini-grids deployment in rural areas. • Manages mini-grid project cycles, channels loans and grants for mini-grid projects (e.g., through a rural electrification fund). • Monitors and evaluates mini-grid projects.
Local authority/ Administration	• Supports the identification of target areas. • Authorizes land and water use. • Awards building permits. • Awards resource utilization permits, e.g., water rights. • Promotes mini-grid programs. • Facilitates contact with electricity end consumers.
Mini-grid companies or micro-utilities	• Obtain sites for each respective mini-grid and for upgrading their infrastructure. • Request licenses where needed. • Collaborate with investors, financial institutions and authorities to develop projects. • Install and operate mini-grid assets and supply electricity to customers.
Gender Focal Points	Within a ministry: • Coordinates gender mainstreaming activities for their sector and coordinates holistically with other GFPs nationally across sectors. • Supports planning, implementing, and monitoring and evaluating mandated gender mainstreaming strategies and actions to be carried out within the ministry. • Provides guidance to other ministries on selection criteria for GFPs, which sometimes include: – Two GFPs, including one woman and one man. – Strategic placement of GFPs with decision-making power and influence in planning and budgetary decisions. – Some experience or demonstrated knowledge of gender equality and mainstreaming. GFPs may be placed at the ministry level only, or in some instances may also be embedded within ministry departments or institutions. GFPs are often not trained gender specialists and often have competing job duties. As such, they often engage the expertise of local and international gender experts, the ministry of gender or women, and international and national government organizations (NGOs) to support in-depth technical work.

GUIDELINE - ENERGY SECTOR INSTITUTIONAL STRUCTURE

The large-scale deployment and regulation of mini-grids for rural electrification requires the adoption of a clear institutional framework that defines the role of each actor in the design and implementation of a national rural electrification strategy. Ensuring a well-coordinated arrangement among the institutions in question is essential to ensuring efficient performance.

3.2 OFF-GRID POLICY AND STRATEGY

Countries have adopted a range of approaches to the development of mini-grids, aiming to extend energy access to underserved areas or communities. Existing regulations, however, have often been inadequate to de-risk and finance such investments.

Off-grid renewables need to be woven into regional and national electrification planning processes as early as possible, particularly to make optimal use of decentralized solar, wind, hydro, and/or any other source of power. National rural electrification strategies, meanwhile, should incorporate specific policy and regulatory frameworks for renewable energy mini-grids.

Key factors to consider include legal and licensing provisions, tariff regulations, financial support, quality standards and eventual grid interconnection or arrival of main grid. Complementary efforts are needed to build capacity across the entire value chain (from financing institutions to local communities), to identify cross-sector linkages, and to ensure sustainability. As mini-grid experience grows, policy review and design should continually incorporate the latest lessons.

By 2016, about 133 million people were served by off-grid renewables, with about 2.1 million people connected to solar photovoltaic (PV) mini-grids. Between 2008 and 2016, the number of people connected to mini-grids tripled to nearly 9 million across Asia and grew six-fold to 1.3 million across Africa.[2]

CHALLENGES

- Lack of recognition and appreciation that mini-grids can advance government electrification strategy.
- Convoluted licensing processes and unclear requirements on regulated versus non-regulated projects and the registrations needed to undertake an electricity supply activity.
- Absence of demarcation of areas to be targeted by off-grid mini-grids.
- Absence of clear grid expansion plans.
- Absence of dedicated rural electrification entities.

CURRENT STATUS

- The off-grid policy and strategy are available and off-grid licensing is practiced in some countries, with some special cases noted.
- Mini-grid development in several countries is still at its infancy. However, observations from reference and case study countries indicate that the policy and strategy framework for mini-grids is embedded in their overall energy policies and rural electrification strategies.
- Several countries have anchored their mini-grid development initiatives within the SE4All universal access targets. Some countries, including Kenya, Rwanda and Senegal, have developed ambitious targets by ensuring that universal access is achieved by 2022, 2024 and 2025, respectively.

[2] Policies and Regulations for Renewable Energy Mini-grids, International Renewable Energy Agency, October 2018.

TABLE 3.2: COUNTRY STATUS FOR OFF-GRID POLICY AND STRATEGY AND LICENSING

COUNTRY STATUS FOR OFF-GRID POLICY AND STRATEGY AND LICENSING

OFF-GRID POLICY AND STRATEGY AVAILABILITY	OFF-GRID LICENSING PRACTICED	COMMENTS/ SPECIAL CASES
Valid in: • Cambodia • Kenya • Nigeria • Rwanda • Senegal • Tanzania • Zambia	Valid in: • Cambodia • DRC • Kenya • Nigeria • Senegal • Tanzania • Zambia	• **DRC:** Has never developed a national electrification policy for rural and peri-urban areas. • **Ethiopia:** The off-grid electrification strategy being developed as part of National Electrification Plan was supposed to be adopted by July 7, 2019. At the time of writing, the strategy has not been adopted. • **India:** An off-grid policy and strategy does not exist, but there are several initiatives to encourage off-grid capacities. The license requirement was removed for power generation (in all areas) and power distribution. • **Rwanda:** The mini-grid sector is nascent and all mini-grids operating in the country are exempted from licensing.

SUCCESS/FAILURES

- A policy focus that responds to the requirements of rural electrification and mini-grids specifically has resulted in fast tracking mini-grids penetration in several countries. In Tanzania, Kenya and Rwanda, for example, policies have prescribed the path for engagement in this sub-sector and include a legal and regulatory framework, licensing requirements, and compensation mechanisms when the grid reaches the mini-grid's territory and are attracting more investments.
- Policies and strategies in Rwanda, Senegal and India, for example, have allowed light-handed regulation and have also encouraged quick investment in mini-grids. In India, in addition to an ambitious 20,000 MW target for grid-connected solar PV systems, the installation of 2,000 MW of off-grid solar PV systems is targeted by 2020.
- On the other hand, in countries like India and Senegal, policies are still focused on the electricity grid. Without deliberate strategies on universal electricity access that call for off-grid solutions, these countries are still struggling.
- One other challenge that tends to result in potential failure is the lack of productive uses by consumers, which often renders mini-grids economically unviable due to limited demand

LESSONS LEARNED

- In some countries on- and off-grid electrification targets are not distinguished. Others, like Rwanda, have set targets. Rwanda states that 62% of electricity access should be generated by off-grid systems by 2030.
- The demarcation of off-grid areas is important for the design and implementation of an off-grid electrification policy.
- A specifically drafted off-grid electrification strategy gives the private sector a clear vision of government objectives.
- Off-grid solutions must be developed quickly to achieve universal access, which requires strong commitments from policy makers. They must consider providing such support as special incentives and subsidies where necessary. Without government involvement, it may take a long time for mini-grids to develop, if at all.

GUIDELINES FOR MINI-GRID POLICY AND IMPLEMENTATION STRATEGIES

The implementation of rural electrification policies, including off-grid solutions, requires a clear strategy that identifies the territories that grid extension would reach within a reasonable time frame and the areas suitable for off-grid installations. This saves time in making decisions while also reducing uncertainty and providing clarity to both grid and off-grid project developers. The interplay between stand-alone and mini-grid installations in rural areas is another important element that needs to be considered within the national electrification strategy. Stand-alone systems can often stimulate electricity demand, thereby improving the economic case for mini-grids. Similarly, mini-grids can be further integrated into regional mini-grids or the main grid, where technically feasible.

- Energy policy and rural electrification strategies should be inclusive of off-grid solutions.
- The government's institutional set-up should be structured to include clear oversight of off-grid initiatives to ensure systematic implementation.
- Capacity building should be strengthened along the entire value chain to enable effective implementation and sustainability.
- Rural electrification targets should be set and performance monitored.
- Technological reviews should be undertaken carefully and systematically.
- Enabling investment environment (including incentives) should be enhanced and well elaborated to encourage strong and effective private sector engagement in this subsector.
- Stakeholder engagement with beneficiary communities, the private sector, civil society, academia, etc. should be conducted.
- Investment barriers – including capital requirements, tariffs, and subsidy requirements – should be examined to ensure the effective implementation of rural electrification strategies to include mini-grids.
- Different financing mechanisms and investment models should be assessed to inform decision-making.

3.3 LEGAL AND REGULATORY FRAMEWORK

The legal and regulatory framework mainly constitutes the regulations and obligations pertaining to sector activities' execution including investments. It is important that the legal and regulatory framework remains transparent and that the regulations' requirements and obligations are enforced. This pertains to several aspects including licensing for power generation and/or distribution and trading, tariff regulation, obligations related to the utilities and other energy service providers, etc.

The capacity range covered within mini-grid regulations demonstrates a general trend toward an integrated system of regulation where, on the one hand, small mini-grids are exempted or subject to light-handed regulation and on the other, large mini-grids may be regulated in the same manner as the utility.

CHALLENGES

- In several countries, regulation of the off-grid sector is lacking or is insufficient.
- Lack of publicly available information, guidance, regulations, procedures, requirements for private companies.
- There are still difficulties in coming up with a common and standardized understanding of the level of regulation for mini-grids. Some countries' regulations go as high as 10 MW in defining mini-grids, while others stop at 1 MW.

- Lack of clear tariff setting or guidance as well as tariff tools that guide investors is a challenge in some countries.
- Legal and regulatory guidelines on compensation mechanisms when the grid encroaches the mini-grid's territory are still not well defined in some countries.

CURRENT STATUS

The table below provides an understanding of mini-grid definitions in six countries.

TABLE 3.3: MINI-GRID DEFINITIONS

MINI-GRID DEFINITIONS

LEGAL AND REGULATORY FRAMEWORK	GENERATION CAPACITY	COMPLIANCE	COMMENTS
Definition of mini-grids	Operating generation system up to 1 MW capacity	• Kenya • Nigeria • Rwanda • Tanzania • Zambia	**Ethiopia:** has no clear definition of mini-grids. **India:** Mini-grids are defined as an isolated or interconnected grid with between 10 kW and 25 kW of generation capacity.
	Operating generation system up to 10 MW capacity	• Cambodia	

SUCCESS/FAILURES

- The existence of a clear legal and regulatory framework provides a conducive environment for investment. Tanzania and Rwanda have been particularly successful in coming up with clear regulatory guidance, where regulations distinguish between licensing versus permits for commercial use. When the mini-grid system capacity is below a certain threshold, only a registration is required.
- Exercising light-handed regulations based on capacity has eased the regulatory burden. To this effect, mini-grid projects with capacities less than or equal to 100 kW are generally exempted from regulation and only require submitting basic project details to the regulator.
- Failures have been noted in countries where the licensing and permitting process is highly bureaucratic and receives no direct support from the government.
- Observing standards for equipment and appliances used is also still an issue that hinders sustainability.
- Rwanda, Tanzania, Uganda, Kenya and Nigeria have guidelines simplifying regulations for small off-grid projects.

TABLE 3.4: MINI-GRID LICENSING BY CAPACITY

MINI-GRID LICENSING BY CAPACITY

COUNTRY	LICENSING BASED ON CAPACITY (MW)
DRC	• Approvals for licenses are granted by the provincial authorities and processes remain the same regardless of the capacity • Generation capacity of less than 10 MW in remote areas = mini-grid. • Generation capacity between 1 and 10 kW in remote areas = micro-grids
Morocco	• N/A: "Mini-grids were from the beginning supposed to be an integrated part of the solution, and projects for mini-grids supplied by mini-hydro, diesel and hybrids between diesel, solar and wind were initiated in 2002-2004. However, at the end mini-grids and the experimental technical and organizational solutions seemed to have been supplanted by the grid-connection approach of the operator, Office National d'Électricité (ONE)."[3]
Tanzania	• Licenses are not required for mini-grids with less than 1 MW of electricity generation during registration, while those under 100 kW are exempt from tariff approval. • Tanzania's Electricity and Water Utility Regulatory Authority (EWURA) has promulgated a system comprising regulations, standardized contracts, and avoided cost-based, non-negotiable tariffs pertaining to private, small (under 10 MW), renewable energy power projects to supply the TANESCO grid and enable these entities to supply electricity directly to isolated rural communities. • According to EWURA, a small power project (SPP) is defined as a power plant that uses a renewable energy source either directly or through the cogeneration of heat and electricity, with an export capacity of up to 10 MW.
Zambia	• Micro-grids (5–20 kW) — for up to about 100 customers • Mini-grids (20–10,000 kW) — for 100+ customers

TABLE 3 5: COUNTRY CASES FOR SIMPLIFIED REGULATION, ESPECIALLY FOR SMALL PROJECTS

COUNTRY CASES FOR SIMPLIFIED REGULATION, ESPECIALLY FOR SMALL PROJECTS

COUNTRY	< 50KW	50 < P < 100KW	100 < P < 1000 KW
Kenya	Licensing compulsory		
Nigeria	Registration		Permitting, main grid compatible
Rwanda	Exempt from license, registration only for information	Simplified licensing framework, unsolicited bids and application for concession agreement	Simplified licensing framework, concessions awarded through competitive tender, unsolicited offers allowed and evaluated on a case-by-case basis
Tanzania	Exempt from license, registration only for information.		
Uganda	No license below 500 kW, registration not compulsory. Below 2 MW, possible application for license exemption.		

[3] Utility-led rural electrification in Morocco: Combining grid extension, mini-grids and Solar Home Systems, Ivan Nygaard, Technical University of Denmark, March 2015.

LESSONS LEARNED

- The existence of a clear legal and regulatory framework provides a conducive investment environment.
- Exercising light-handed regulations based on capacity eases the regulatory burden. Small power projects need to be exempted from heavy-handed regulation.
- Regulations need to be clear and provide guidance on licensing and permitting processes, tariffs, service area allocation, options for mini-grid development companies when the national grid arrives, and valuations.

GUIDELINES – LEGAL AND REGULATORY FRAMEWORK

- It is important that the legal and regulatory framework is transparent, and that the regulations' requirements and obligations are enforced. This pertains to licensing for power generation and/or distribution and trading, economic regulation, obligations related to the utilities and other energy service providers.
- Regulatory frameworks need to include electricity pricing and describe the allowed business models and permitting procedures. It is important that regulations provide for a mini-grid license/permit that covers generation, distribution and sales of electricity to end-users.
- Simplified regulations for very small size projects can speed their deployment.
- There should be a legal framework that provides for a situation when the grid encroaches the mini-grid service territory
- It is important to have a legal and regulatory guidance on provision of incentives and subsidies
- Streamlining licensing and permitting processes to minimize authorizing entities is key in facilitating investors
- Developers need to be transparent (to the regulator) in their investment / financing and tariffing. Structures. This is important in protecting the end user consumers
- It is important that regulations state the threshold capacity above which the retail tariff must be regulated.

LESSONS AND PRACTICES: THE SOUTHERN AFRICAN DEVELOPMENT COMMUNITY (SADC) CASE

From the foregoing discussion, it is evident that a best practice environment is needed to encourage investment and foster the growth of mini-grids. This environment has many different dimensions. From a practical perspective, the specific items that can be addressed are listed in the Summary Guidelines above.

TABLE 3.6 : INSTRUMENTS REQUIRED FOR A BEST PRACTICE MINI-GRID ENVIRONMENT

INSTRUMENTS REQUIRED FOR A BEST PRACTICE MINI-GRID ENVIRONMENT

FOCUS AREA	IMPORTANCE	MAIN INSTITUTIONAL RESPONSIBILITY	POLICY, PLANNING AND REGULATORY INSTRUMENTS
Role clarity	Primary	Ministry or agency that decides on energy policy and plans	Guidelines for planning and development of mini-grids
		Rural and Renewable Energy Agency and/or mini-grid developers	Template for assessing consumer needs and demand
	Secondary	Regulatory authority, licensing authority	Guidelines to appraise the demand analysis in a feasibility study of project
		Rural and Renewable Energy Agency	With guidance from the Ministries responsible for Energy and Finance, provide guidelines for use of rural funds for targeting subsidies[4]
Choice of technology	Primary	Ministry or agency that decides on energy policy and plans	Terms of reference template for renewable energy resource assessment
		Rural and Renewable Energy Agency and/or mini-grid developers	Comprehensive assessment of technology options
	Secondary	Regulatory authority	Technical design and operational guidelines
		Rural and Renewable Energy Agency and/or mini-grid developers	Guidelines for grid interconnection
			Guidelines for technology transfer
Ownership and financing	Primary	Ministry or agency that decides on energy policy and plans	Mini-grid procurement guidelines (including feed-in tariffs, quotas, competitive bidding, first come first served, etc.)
		Rural and Renewable Energy Agency and/or mini-grid developers	Guidelines for use of energy funds for investment (including capital subsidies, carbon credits, tax concessions, fiscal incentives, etc.)
	Secondary	Regulatory authority	Standardized tariff methodologies and power purchase agreements

[4] While REAs are often implementing agencies and beneficiaries of funds, in many cases, REAs develop proposals for fund's utilization mechanisms, and/or oversee the implementing entities, including the private sector. Proposals for utilization of funds are generally subject to approval by both ministries responsible for energy and finance.

3.4 LICENSING AND SERVICE TERRITORY ALLOCATION

Regulations provide clarity on when a license is required and when only a registration is needed to undertake any electricity supply activity. Only India has removed the license requirement for power generation (in all decentralized renewable generation areas) and power distribution (in rural areas).

In many cases studied, the process of obtaining a license is described in legislation along with the information required. Site allocation for installation of a power generation plant or power distribution network is provided through a concession for a certain duration. The licensing regime that follows the broader legislation or energy act is normally prescribed in the regulation. Small capacity installations tend to be exempted from licensing but must be registered. In almost all reference and case study countries, license conditions include the adoption of national technical standards, tariffs, service standards, service territory, and a buy-out clause where encroachment is envisaged.

CHALLENGES

- Heavy-handed regulations that impose a heavy burden on obtaining licenses are still an issue.
- Policies that do not provide for the consideration of special support to small power producers make it difficult for investors to succeed.
- license to be issued may not be known in some countries.
- Where there are no clear demarcations, power master plans that define the grid and off-grid territories often present barriers to mini-grids developers, especially when the grid arrives to their territory. Also, the time it takes for the government to offer the investment territory to mini-grid developers as free spaces for investments may not be clearly known.

CURRENT STATUS

- In the site allocation process for mini-grids, only the DRC prohibits unsolicited applications (a bottom-up approach). Most countries in the nascent stages of mini-grid development accept unsolicited projects to attract private investment in underserved areas.
- In majority of the countries examined, a first-come first-served approach is prevalent. Only Ethiopia has chosen to allocate sites based on sites procured by the mini-grid developer, while most of the other countries are also beginning to use concessions allocated after a competitive process.
- All countries except Zambia require a mini-grid to have a license for each site, e.g., where the sites are in different counties/provinces.
- Not all countries have provisions on compensation mechanisms regarding the relationship between authorization type and compensation mechanisms to mini-grid operators. For most of them, compensation is independent of authorization type, but generally is about whether one has a permit. Where there is compensation, it depends on the option taken by the mini-grid operator upon grid encroachment. But the following significant exceptions are noted:
  - The compensation in Cambodia is based on tariff bonuses.
  - The relationship between authorization type and compensation mechanisms is nonexistent in Zambia.
  - The situation where the national grid will have reached the mini-grid territory is yet to be settled in DRC and Rwanda.
  - No clear compensation mechanism has been defined in Senegal.
- Generally, the first-come first-served approach is used for feasibility studies and fundraising provision, so no provisional authorization is sought before a feasibility study. In most countries, a feasibility study must be part of the application for authorization. Upon seeking authorization, and after the feasibility study is completed, developers may go for fundraising. The authorizations are issued by regulators with following exceptions in:
  - DRC – authorization is issued by the provincial governments.

  - Senegal – the regulator provides a non-objection of authorization followed by a request to the energy ministry.
  - Ethiopia – there is no clarity on this matter.
- The costs of licensing or authorization vary from country to country and the basis on which costs are levied also varies. It is the norm for regulators to charge a levy to cover their costs. No blanket exemption for levies for mini-grids is allowed. Specific exemptions for mini-grids below a certain capacity exist in:
  - Kenya, where permits are issued for less than 3000 kW capacity and are free of charge.
  - Tanzania, where the micro-utilities operating as micro-grids are exempt from licensing requirements. They pay application fees for registration which are nominal compared to licensing fees.
- In Ethiopia, it is common for developers to compete for concessions that are eligible for subsidies from governments or donors funding. The winners of procured mini-grid sites are required to apply for authorization following the standard licensing procedure in the reference and case study countries. Sometimes, several levels of government (national, provincial, county) have jurisdiction over the issuance of authorizations.

SUCCESSES/FAILURES

- The existence of clear legal and regulatory framework informs the licensing processes, including the time within which licenses should be issued. Tanzania, for example, has been particularly successful in coming up with clear regulatory guidance to this effect, where the regulations distinguish between licensing versus permits for commercial use. When the mini-grid system capacity is below a certain threshold, only a registration is required.
- Exercising light-handed regulation based on capacity has eased the regulatory burden. Mini-grid projects at or under 100 kW are generally exempt from regulation and only require submitting basic project details to the regulator.
- Failures have been noted in countries where licensing and permits issuance is still bureaucratic and receives no direct support from the government.
- Some subsidies by development partners are channeled through the government for the benefit of mini-grid developers.
- The subsidies will generally be contingent on a developer having a license.

TABLE 3.7: LICENSE PROCESSING DURATION BY COUNTRY

LICENSE PROCESSING DURATION BY COUNTRY

COUNTRY	DURATION TO OBTAIN LICENSE
Senegal	Information not available
Tanzania	• No license required. • A typical mini-grid project may involve up to 13 steps from inception to commissioning. Clearances and decision-making processes involve multiple institutions outside the energy sector; some regulatory procedures (such as obtaining environmental clearances) can take several months.
DRC	Information not available
Zambia	• If an Environmental Impact Assessment (simplified or full) is required, Zambia's Environmental Management Agency (ZEMA) has 14 days to respond after receiving the environmental assessment. • If ZEMA responds with comments, the developer addresses the comments and then re-submits its application. ZEMA then has 40 days to accept/reject the decision; if it fails to give feedback, the developer can proceed with its project. • This process can take longer than the official timeline. For one mini-grid developer, EPB, approval took eight months. • The official timeline for license issuance is 60 days from receipt of application. This consists of 30 calendar days for Energy Regulatory Board administrative processes and a 30-day statutory announcing period. In some cases, a license could take longer to obtain, for example, if the Gazette delays in publishing the notice.
Morocco	Information not available

LESSONS LEARNED

- The process of acquiring a mini-grid site does not change with the size/capacity of the mini-grid. The changes are from the point of licensing and tariff approvals. Some regulators do not require a license below a certain capacity, but they do require that these mini-grids be registered.

GUIDELINES: LICENSING AND SERVICE TERRITORY ALLOCATION

- Site allocation/reservation approaches should be open to both solicited and unsolicited options following the criteria set forth including the nature and level of demand.
- A time-limited provisional license/registration/permit for site reservation or allocation should allow developers to carry out feasibility studies and seek funding for construction, but at the same time protects communities from being taken advantage of by developers.
- A concession agreement providing for occupation of the location and duration of the concession should be entered upon commissioning of the mini-grid and start of operations.
- Countries should have a centralized website location to guide developers through the licensing process, to include required non-electricity sector licenses or registrations.
- Countries should simplify the licensing process for private sector developers to ease the licensing burden and reduce costs for developers. Some examples could include:
  - Creating a one-stop shop to reduce the number of entities that the private sector developer must interact with.
  - Creating regulations that allow developers to obtain one license for multiple project sites and potentially de-risk projects through diversification.

4. MINI-GRID BUSINESS AND FINANCING MODELS


Photo: © AdobeStock.

The section describes the business and financing models used in mini-grid infrastructure development in the case study and reference countries, the challenges these models experience, and their success factors.

Policymakers should consider the success of mini-grids, both from the perspective of increasing universal access to electricity and the financial viability of the mini-grid that is providing the service, because electrification is not just about making money, it is also a social imperative. Achieving both commercial viability in tandem with extending universal access to electricity may require innovative business/financial models coupled with capital expenditure (CAPEX) and operating expenditure (OPEX) subsidies.

4.1 BUSINESS MODELS

In assessing mini-grid business models, the study examines the ownership and operating models, customers, operating revenue sources and levels, competition, and what makes these mini-grids successful or unsuccessful.

CHALLENGES

Current mini-grid business models face several challenges that impact the ability for rapid expansion. These are:

- Mini-grid technologies and markets are still in the early stages, causing investors to be uncertain about the economic viability of mini-grids.
- The lack of consistent business model metrics across investment opportunities and markets inhibits evaluations of how mini-grids have performed over time.
- Market-risk related challenges include 1) uncertainty about which anchor/productive load models could be viable, 2) insufficient economic growth to drive demand growth, and 3) the application of the power purchase agreement (PPA) model to off-grid/mini-grid operation.

COUNTRY STATUS

The following are ownership and operating models being used in the focus countries:

Mini-Grid Ownership and Operating Models

Mini-grid delivery approaches yielded various ownership and operating models in the countries studied. The following three delivery approaches are used in mini-grid development in India:

- *Build-own-operate* – the developer builds, owns and operates the mini-grid for the lifetime of the investment. The developer installs the plant system and employs its own staff to operate and collect payment from end-users.

- *Build-operate-transfer* – the developer installs the plant system, operates it for a defined period, then transfers ownership to a third party. The transfer could occur at the end of concession/license period, some other understanding, or upon grid arrival.
- *Build only* – The developer installs the plant system and transfers ownership to a third party (village community, government, local entrepreneur, NGO, etc.) and might provide some maintenance and after-sales support.

These three delivery approaches give rise to the following ownership and operating models:

Ownership models

- *Privately owned,* the owner built or bought the mini-grid using cash on hand or debt and equity raised from private markets that needs to be repaid at market rates.
- *Community-ownership model*, the community (in the form of a cooperative or a community based organisation (CBO) or local representatives) owns the mini-grid and the financing comes through a combination of government grants, international donor funds or community in-kind contribution of land and/or labour.
- *Publicly owned*, through a state-owned utility or rural electrification authority or county government owns the mini grid.
- *Private Special Purpose Vehicle (SPV)* – "comprises of a legal entity created by the sponsor or originator to fulfil a temporary objective of the sponsoring firm. SPVs can be viewed as a method of disaggregating the risks of an underlying pool of exposures held by the SPV and reallocating them to investors willing to take on those risks. This allows investors access to investment opportunities which would not otherwise exist and provides a new source of revenue generation for the sponsoring firm".[5]

Operating models

- *Private operated-self or service contract* – the private sector owner operates the mini-grid. This owner can also opt to appoint another entity to manage the mini-grid on its behalf through a service contract.
- *Community operated* – the community that is using the electricity operates the mini-grid through a community cooperative or a community based organisation (CBO) or local representatives. This is common with mini-grids initially funded by government or donors.
- *Faith-based ownership operating model*- a religious or church organization that owns the mini-grid also operates it.
- *Public through state-owned utility* – the public utility operates and maintains the mini-grid and would also collect the tariff. This can be beneficial since utilities have the needed technical expertise to operate and maintain the grid and greater access to funding. Unfortunately, without a government mandate, they are likely unwilling to expand mini-grids because it is cost prohibitive.
- *Franchisee model* – In this model, a mini-grid operator distributes electricity to end users on behalf of the utility. The customers pay their bills directly to the national utility company (franchisor). The mini-grid operator (franchisee) is paid an operating fee for their service. The franchise agreement will have performance targets/ incentives to ensure alignment between franchisor and franchisee expectations. For example, the operating fee may include a performance bonus where the grids' revenues exceed projections, or an efficiency bonus for the operator to benefit from operating the mini-grid more efficiently and providing customers with better service.

[5] Creating an Understanding of Special Purpose Vehicles, PwC, December 2011

TABLE 4.1: OWNERSHIP AND OPERATING MODELS

OWNERSHIP AND OPERATING MODELS

OWNERSHIP MODEL	OPERATING MODEL	EXAMPLES
Private	Self (private)	**Cambodia** – Since the 1990s mini-grid operators build, own, operate, maintain and finance their systems. **India** – Build-only models are the most common because enterprises can immediately recover CAPEX costs. The second-most common model is build-own-operate, while the least common is build-operate-transfer. **DRC**, **Kenya**, **Nigeria**, **Rwanda**, **Tanzania**, and **Zambia**.
	Service contract	No information available
Private Special Purpose Vehicle (SPV)	Service contract	Powergen for the CrossBoundary Energy Access (CBEA) SPV in **Kenya**.
Public Private Partnership Special-purpose Vehicle (SPV)	SPV (proposed)	**Zambia** – as part of the road testing of the new mini-grid regulations
Public (Utility or REA, or County Government)	Public - utility	No information available
	Public - REA	No information available
	Franchise	**Kenya** Off-Grid Solar Access Project (KOSAP)/KPLC.
	Service contract	**Kenya** – Talek
	Community Cooperative	**Zambia** – Mpanta
Faith-based	Faith-based	No information available
	Community	**Zambia** – The Catholic church built and operated a community clinic and developed a mini-grid to supply electricity to this clinic. The church operated the mini-grid and transferred it to the community. Ownership and operation changed over to the community model described above.
Community (in the form of a cooperative, community based organisation or any other form of community representation)	Community	**Ethiopia** – Energising Development (EnDev) has established five operational community-owned mini-hydro schemes: four in Sidama and one in Oromia Gima. **Kenya** – Renewable World is operating four energy hubs in Kenya, owned by communities. **Rwanda** – One community-owned hydropower project remains, although it is likely that it will be connected to the grid soon. **Tanzania** – Community-owned and operated mini-grids are one of the recognized models. **Zambia** – A state-funded (through the REA) mini-grid is operated by the community, organized as a community cooperative.

Franchisee Operating Model

The franchise operating model is not operating in any of the focus countries. While it is under consideration, the timeline for operationalization is uncertain.

- In Senegal, four concessions allocated to SENELEC will be operated, most likely under the franchisee model. It is anticipated that this model will ease the implementation of harmonized national tariffs.
- In Kenya, about 140 mini-grids will be financed under the World Bank-funded Kenya Off-grid Solar Access Project (KOSAP) involving the private mini-grid operators that may work as franchisee to Kenya Power and Light Company.
- Tanzania, Nigeria and Kenya have drafted mini-grid regulations that include the option of a franchisee model, when the national grid arrives, and the mini-grid is interconnected to the national grid.
- In India, one of the two existing options for mini-grids is to export all power to the main grid when the national grid arrives, with the possibility of the mini-grid becoming a distribution franchisee.

It is noted that most countries allow more than one of the above ownerships and operating models.

Mini-Grid Customers and Operating Revenues

From a revenue perspective, the two key drivers of mini-grid commercial business models are the volume of electricity (kWh) sold and the tariffs charged.

- Productive use customers like health centers, mills, and timber producers drive higher kWh consumption for mini-grids. In addition, connecting the surrounding community households, businesses-shops/restaurants, and institutions such as schools also increase kWh consumption. Mini-grids connected to the national grid, particularly the publicly owned ones, dispatch to the national utility where electricity is sold from the national grid. If the public utility is financially viable, these mini-grids have more certainty of offtake than theoretically improving their commercial viability.
- Tariffs are a major driver of mini-grid revenues. The predominant source of operating capital/revenues for mini-grids is tariff revenues from the connected customers (mostly rural households). However, mini-grid locations tend to be remote, have low population density, and are unelectrified rural areas where the main customer base is low-consumption rural households. In addition, securing cost-reflective tariffs from regulators is still a challenge to the mini-grids that undermines commercially viable business models. The following table shows the current status of mini-grid operating capital in focus countries.

Mini-grids are testing various models for increasing the productive use of electricity such as appliances (e.g., electric cooking stoves, fridges, television and home entertainment systems) leasing to shore up electricity consumption. Financing appliance leasing and private lending come with their own working capital demands and will require partnerships with leasing companies or NGOs. Except for the mini-grids with productive use anchor customers, the mini-grids are not generating enough operating revenues to meet their operating expenditures, recoup investment, or make a commensurate return on investment.

TABLE 4.2: MINI-GRID CUSTOMERS AND OPERATING CAPITAL

MINI-GRID CUSTOMERS AND OPERATING CAPITAL

CASE STUDY/ REFERENCE COUNTRY	REVENUE SOURCES
Cambodia	Sources speak of 600 mini-grids, connecting 180,000 households (roughly 0.9 million people) and 7,000 businesses. In addition to electricity sales revenues, many licensees are engaged in other businesses (for example, private lending, or agribusiness).
Ethiopia	The five mini-hydro grids have residential, institutional and business customers. Their source of operating capital is EnDev donor grant funding.
India	Customers types are residential, institutional, business, productive use and anchor, such as mines, timber mills, agri-processors and big businesses. They generate operating capital from the existing connected customers as well as an innovative tariff design that provides some grant funding from corporate social responsibility and shared value programs to ensure mini-grid continuity.
Kenya	Operating capital is generated from connected customers. The grid connections are cross-subsidized through a uniform tariff with the national utility tariff. The mini-grids have residential customers, institutional customers, and businesses as anchor customers. However, households consumption is very low, with some mini-grids reporting household consumption of less than 1 kWh per month.
Nigeria	Most mini-grid customers include both households and businesses. Economic activity is one of the key parameters that one developer, GVE, looks at when choosing a site. One mini-grid developer plans on having 89 commercial and industrial customers. Nayo's mini-grid in Awka provides power exclusively for productive customers, notably timber producers. Its operating capital is generated from connected customers.
DRC	Tshikapa's mini-grid was planned to serve the parent mining company. The neighboring households are connected as part of the mining company's corporate social responsibility engagement. Revenues are mainly from the mining company with some from connected households.
Rwanda	The overall consumption of energy and ability to pay in rural areas is very low, e.g., in some Rwandan households, demand ranges from 2 kWh–7 kWh/month.
Tanzania	Customers are productive use anchor customers, mainly mines, and connected neighboring households. The revenues mainly come from these connected customers.
Zambia and Senegal	The main customer base is rural households plus a few productive uses by businesses and institutions. These customers are the mini-grids' main sources of operating revenues.

Off-Grid Mini-Grid PPA

- An off-grid PPA model is not in place in any of the countries studied, but it is under consideration in Kenya and Ghana. An off-grid/mini-grid PPA will facilitate the harmonization of tariffs.
- Specific new institutional arrangements will be required for off-grid PPAs, which are not currently in place and may take some time to put in place.
- The new institutional arrangements required for off-grid PPAs include:
  - Mini-grid operators that are separated into generation (small power producer, SPP) and distribution (small power distributor, SPD) entities. The SPP feeds power to the distribution grid and bills the utility at the feed-in tariff. The SPD buys off the distribution grid, pays the fund at a bulk tariff, and sells to the end user at the regulated tariff, e.g., the uniform national tariff.
  - The electricity sector regulator should define an off-grid feed-in-tariff for the SPP and a bulk sale tariff for the SPD, that allow these entities to be financially viable.
  - A tariff harmonization fund is necessary at the beginning to absorb the difference between the feed-in tariff and the bulk tariff.
  - This tariff harmonization fund could be a rural electrification fund (REF) or an off-grid electrification fund, or any other public fund for that purpose.

Mini-grid Competitors and How a Mini-Grid Differentiates from its Competitors

While national grid encroachment remains a source of competition for mini-grids, mini-grid projects also face competition from other off-grid technologies like stand-alone solar home systems (SHS) with or without rechargeable batteries, as well as pay as you go (PAYGO) SHS and LPG cookstoves.

Interviews with stakeholders within DRC and Rwanda indicated that mini-grid developers experience competition from other mini-grids. Competition between mini-grid projects is an indication that there may be challenges with existing mini-grid site allocation. Although competition is good for consumers, governments should set parameters on the locations where SHS PAYGO programs are rolled out to avoid cannibalizing the mini-grid market or encouraging wasteful duplication of investment of limited capital resources.

TABLE 4.3: MINI-GRIDS COMPETITORS

MINI-GRID COMPETITORS

MINI-GRID COMPETITORS	COUNTRY EXAMPLES	HOW MINI-GRID DIFFERENTIATES ITSELF
Solar Home Systems (SHS) with or without rechargeable batteries – outright purchase	• DRC, India, Kenya, Nigeria, Rwanda, Tanzania, and Zambia • In Cambodia, competition is from SHS plus rechargeable batteries. Mini-grids appear to be very competitive, especially with regulations guaranteeing quality technical standards.	Higher level of service than competing SHS
PAYGO solar home system	Zambia	
LPG cookstove	Zambia	
National grid	Kenya – Powerhive Rwanda Others – only on grid arrival	Higher level of service than national grid

Table 4.4 summarizes what makes a mini-grid successful or not. For policymakers, it is important to note that success should be pre-defined because electrification is not only about attracting private investment and ensuring the commercial viability of mini-grid projects, but also ensuring that social needs are met in a cost-effective manner.

TABLE 4.4: WHAT MAKES MINI-GRIDS SUCCESSFUL/UNSUCCESSFUL

WHAT MAKES MINI GRIDS SUCCESSFUL/UNSUCCESSFUL

COUNTRY	WHAT MAKES THEM SUCCESSFUL	WHAT MAKES THEM UNSUCCESSFUL
All	Reliability of the power supply and its usability for productive use is key to the mini-grid's commercial success.	
Cambodia	Operating subsidies are key. The regulator still computes the cost-recovery tariff of each mini-grid; the difference between this and the standardized tariff is to be covered by the REF.	Profit margins seem to be tight.
DRC	Captive consumer: The micro-utility is able to provide power where there is none. For example, the productive use of power by a consumer as mines increases; the surrounding community gets incomes from direct and indirect employment from the mines that improves these households' ability to pay.	
Ethiopia, India, Kenya, Nigeria and Tanzania	These countries recognize that micro utilities need to adopt energy-intensive usage (productive use of energy) among their customers.	Currently the residential customers' use of electricity is very low and may not cover the costs of the mini-grid developers.
Senegal		Lack of licenses, lack of use of best practice technologies and transparency in the processes.
Zambia	The Zambia government should have started a value addition agribusiness first for the households to have a source of income with which to buy electricity.	The micro utility is struggling because of customers' inability to pay for various reasons: the customers are rural inhabitants with no appreciable economic activity from which to earn income to pay, and the tariff structure is inappropriate.

LESSONS LEARNED

Mini-grid development is in the early stages and business models are evolving with high variability from country to country. There is a recognition that tariffs, and productive uses of electricity are central to the commercial viability of mini-grids. Yet, except for the mini-grids anchored by captive productive users like mines and timber mills, the surrounding community households, businesses-shops/restaurants and institutions have consumption levels generally too low for the economic viability of the rural mini-grids.

There is ongoing experimentation to advance mini-grid business models. The current focus is on the following as drivers of viable commercial business models:

TABLE 4.5: BUSINESS MODELS SUCCESS FACTORS

BUSINESS MODELS SUCCESS FACTORS

SUCCESS FACTOR	SIGNIFICANCE
Affordable tariffs that optimize average revenues per customer.	Commercially viable and improve access
Increasing productive use of electricity.	Commercially viable
A recurrent subsidy where an affordable tariff is lower than the mini-grid's levelized cost of energy (LCOE). The recurrent subsidy will help the investor bridge the gap between the affordable tariff and LCOE tariff. This subsidy is expected to decline over time.	Commercially viable
The service quality and reliability of mini-grids as a competitive advantage over the main grid and solar home systems.	Commercially viable
The off-grid PPA model is another promising area of experimentation, but will require: • A fund to absorb the difference between the feed-in and the bulk tariff. Once this approach is fully incorporated into business models and institutional arrangements, a uniform national tariff structure could be achieved, but this could take several years. • The model is likely to result in higher tariffs. According to Tetra Tech, a preliminary analysis for Ghana has shown that an across-the-board tariff increase of around 2% (off-grid electrification levies) is needed to support this model's implementation.	Commercially viable and improve access
Project finance - investors/lenders provides mini-grids long-term financing against the cash flow that is generated by the mini-grids' assets.	Enable rapid deployment, increase economies of projects
Results Based Financing (RBF)[6]	Per connection subsidy increases access, per kWh subsidy improves commercial viability

As stated earlier, given the objective of achieving universal access to electricity, policy-makers should look at successful business models both in terms of commercial self-sustainability and increasing access to electricity. Successful models should be designed holistically to include one or a combination of:

- On the cost side – the least cost of providing the service or access is achieved through scale, allowing economies of scale.
- On increasing access – reaching rural communities that would not otherwise be serviced.
- Investment side/revenue side – allows the developer access to a wide range of capital with some level of recouping investment (not necessarily a monetary return on investment). This is essential for blending government and donor support with private capital. The private capital element is recouped to release funds for further mini-grids deployment.

[6] RBF is a subsidy paid to the mini-grid against achieving a certain specified performance target e.g., number of customer connections. RBF is given to the mini-grid as a subsidy per connection or subsidy per kWh. An RBF connection subsidy is paid towards reducing the cost to the end user of connection, where the end user cannot afford to pay the full cost-reflective connection cost

GUIDELINES – BUSINESS MODELS

- Policy and regulations should allow an ownership model that protects property rights. Those property rights should be reflected in provisions for willing-buyer-willing-seller with commensurate compensation (i.e., should not be confiscatory) and based on best practices in the mini-grid sector.
- Policy and regulations should be flexible on operating models but issue hard coded operating standards, service reliability and safety standards among other mini-grid performance obligations.
- Regulators have an important role in setting the right tariff, which is an important business model success factor for a mini-grid developer – There is a delicate balance between customer needs, developer economics, and the socioeconomic requirements of the policymaker.
- Policy makers to support stimulating the demand side of electricity by educating consumers on usage of electricity once they are connected as well as support the social enterprises pilots to catalyse productive uses of electricity that at the same time increases incomes of rural dwellers in the mini-grid service areas
- Policy and regulations should be flexible to embrace new business models as they evolve
- Regulation should reinforce a constant drive for mini-grid operational sustainability (permanence).
- Policymakers should be careful not to measure successful business models in terms of commercial self-sustainability. Successful models should be holistic in terms of one or a combination of: 1) costs – the least cost of providing the service, 2) access – reaching the rural communities that would not be serviced otherwise, and 3) on the investment side/revenue side – the ability to source a wide range of capital with some level of recouping investment (and monetary return on investment or impact measurement).

4.2 FINANCING MODELS

Like the business models above, funding models are also evolving. Most mini-grid project developments lack scale, leading to small project sizes to be individually financed. Also, the vast majority of rural mini-grids are not viable without subsidization. As a result, mini-grid developers have struggled to attract long-term financing for their projects. A group of signatory private investors (see Appendix A.4 for a list of these investors[7]) with over $2 billion to invest indicated that for the private sector to provide this capital effectively, their private capital (debt, equity) must be matched by results-based financing (RBF) programs.

RBF is a subsidy per customer connection or subsidy per kWh. This subsidy, which is paid to the mini-grid developer, is vital to increasing universal access, as the RBF is paid towards reducing the end-user's cost of connection where the end user cannot afford to pay the full cost-reflective connection cost. It is a favored approach by private investors who want governments and donors to match the private capital with RBF to de-risk mini-grid deployments. This RBF subsidy is expected to decline over time as new technologies and business models emerge from private sector off-grid companies that improve the economics of rural electrification.

Business models, financing models and the regulatory regime are interdependent. A commercially viable business model with a certainty of revenue streams will unlock additional funding sources from long-term debt capital/ project finance. The regulatory regime is important in providing that revenue certainty from tariffs.

[7] Investor Position Paper: Unlocking Private Capital for Mini-Grids in Africa, July 2019

CHALLENGES

- Lack of access to long-term capital is a significant constraint to mini-grid deployment. It is exacerbated by regulatory uncertainty on the treatment of grid extension into mini-grid service territory, cost recovery through tariffs and ownership rules.
- Limited availability of data on existing mini-grid projects. Income data to provide accurate revenue estimates and model economic returns also impact the proliferation of mini-grids.
- Developers lack the economies of scale to implement several sites at a time that can give them volume discounts from equipment suppliers.
- Finance instruments are not currently designed to attract private investment:
  - Foreign exchange risk guarantees.
  - Political risk guarantees.
- The creditworthiness of the off-taker in the case of grid-connected mini-grids is uncertain. Most of the state utilities have weak balance sheets to underwrite a PPA.

COUNTRY STATUS

Private capital with grants subsidies and government investments incentives/tax rebates are the predominant funding instruments in many countries, but new business models are being tested. For example, the use of project finance and tariff harmonization funds will become mainstream as these instruments are proven.

Sources of seed capital include promoters' own risk capital, debt, equity, grant funding, and government treasury funds. Matching funds from donors/ governments in the form of RBF with private funds, project finance like Powergen, as well as internally generated funds from tariffs for expansion, are additional sources of seed capital.

Off-Grid Mini-Grid PPA

TABLE 4 6: MINI-GRID SEED CAPITAL SOURCES

MINI-GRID SEED CAPITAL SOURCES

OWNERSHIP MODEL	SOURCES OF FUNDING	EXAMPLES
Private	Equity	All
	Government tax concessions	All
	Debt – development finance institution	All
	Debt - commercial banks	Not accessible
	Personal money and borrowed from relatives	Cambodia
Private SPV	Project finance	CBEA - Tanzania
Public Private Partnership SPV	Government or donor funding	Zambia
Public (utility or REA, or county government)	REA	Zambia
Faith-based	Faith-based organization	Zambia
Community	Donors	Ethiopia, Zambia, Kenya

Privately Owned and Operated Mini-Grids

These mini-grids are predominantly commercially funded through equity (some of them up to 100%). There is limited grant funding or government concessions (e.g., tax holidays, duty exemptions). Debt is difficult for investors to access for the reasons stated above.

- In Cambodia, mini-grid developers borrowed money from relatives or their personal contacts at affordable or zero interest rates to finance their activities. Commercial loans are harder to get, with tight requirements on collateral (land title if asking for over 50% of capital expenditure) since assets are of little value to banks, who do not see the opportunity to take over a public service.

- In India, Kenya, Tanzania, mini-grid utilities raised seed capital from equity investors and secured a grant. Some mini-grids in Kenya secured DFI concessionary debt and CAPEX grants. Examples include the Green Mini Grid (GMG) Facility, which funded up to 50% of the CAPEX of mini-grid projects in Kenya and Tanzania, and GIZ ProSolar, which funded up to 50% of the CAPEX of the Talek solar hybrid mini-grid pilot project in Kenya. The GMG Facility is a CAPEX subsidy, but its disbursement is performance based that subsidizes 50% of the mini-grid CAPEX based on the target number of customer connections achieved. Mini-grids in India were getting up to 90% CAPEX grants from governments and donors.
- In Rwanda, seed capital was raised through equity and grants. To date, mini-grids in Rwanda require considerable grant support, ranging from 40% to 70% of CAPEX.

Community Owned or Operated Mini-Grids

Community owned/operated mini-grids are commonly grant-funded by the public or donors. The community provides in kind contributions.

- In Ethiopia, EnDev provided financial resources to cover parts of the investment costs, and the local community contributes civil works.
- In Zambia, the rural community cooperative operates a publicly owned mini-grid on behalf of REA.

Publicly Financed/Utility Operated Mini-Grids

Publicly owned/utility operated mini-grid business models are driven by public good and social considerations such as universal access. Public ownership encourages the implementation of a uniform tariff through cross-subsidies between customer classes.

Publicly owned mini-grids are operated by the rural electrification authority or the national utility (in many cases, they are partly or totally public). They are mostly publicly funded through a rural electrification electricity sales levy, taxes, and/or donor funding through the government.

- In Senegal, the majority of the 400 mini-grids in the rural electrification agency (ASER) pipeline will be 100% funded by the government or donor funded using the engineering, procurement, and construction model. This is still a challenge because there is no seed capital, so some are turning to crowdfunding platforms.
- In Kenya, the rural electrification authority develops the mini-grids and then transfers them to the national utility to own and operate the mini-grids.
- In Zambia, the Rural Electrification Authority has contracted the community cooperative to operate the REA mini-grid but the cooperative is receiving OPEX support from REA.

LESSONS LEARNED

The funding models are still evolving. To date, mini-grid developers have struggled to attract long-term financing for their projects. Most mini-grids projects lack scale, leading to unattractive small project sizes to be individually financed.

The sources of funding have mainly been equity (80%), grants (20%) and occasionally debt from DFIs or program-related investments.[8] Developers are unable to access long-term commercial debt because revenues are unpredictable, and tariffs are often subject to political influence. Measures to attract debt are critical as governments cannot build a sector without debt financing. It is estimated that Africa requires $11 billion to electrify the continent[9] and debt funding is therefore crucial along with other sources of private capital. Funding available for grants is still much smaller than what is required to achieve universal access and lower mini-grids tariffs to parity with national average utility tariffs. Grant support comes in the forms of funding or technical assistance, such as transaction advisory services from international development agencies and institutions.

New Initiatives to Address Financing Challenges

- A position paper, "Investor Position Paper: Unlocking Private Capital for Mini-Grids in Africa," was issued in July by a group of 12 mini-grids investors with over $2.2 billion in investment funds (see the earlier discussion). This group provides the matching private

[8] Africa Mini grid Developers Association, August 2019
[9] CrossBoundary Energy Access and PowerGen Pioneer Long-Term Mini-Grid Project Financing at Scale, July 2019

capital that donor and government-backed mini-grid subsidy programs need in Africa.

- Recently, CrossBoundary Energy Access (CBEA) established a special-purpose entity in Tanzania that will purchase Tanzania mini-grid developer PowerGen's existing and future operating mini-grids in Tanzania, based on the cash flow generated by the mini-grid assets themselves, similar to the traditional project finance model used to finance utilities. The sale of the mini-grids to CBEA soon after completion allows PowerGen to recycle capital and focus on developing more projects. It allows investors and lenders to provide long-term financing based on the cash flow generated by the assets. CBEA is the long-term owner of the mini-grid portfolio and PowerGen will continue to provide long-term customer and asset management services to the mini-grid customers at a fee from the revenues

GUIDELINES – FINANCING MODELS

- Government policy and regulations on tariffs that ensure cost recovery are key to unlocking other sources of funding, especially debt and project financing that will give mini-grids access to required long term financing.
- Adjust regulatory frameworks to embrace new funding initiatives like guarantees and blended finance to unlock capital for the mini-grid sector. The regulatory framework could evolve to support the economics of these new financing models.

4.3 SUBSIDIES AND GOVERNMENT INCENTIVES UTILIZATION

CHALLENGES

Comparisons have been drawn with the USA in 1935, Thailand in 1973 and South Africa in 2001, to correctly make the case that rural electrification has always required subsidy. The economics of rural electrification require subsidies because rural electrification serves:

- Remote, dispersed customers with higher costs to connect
- Households and businesses in rural areas have much lower incomes than those in cities. Revenues from rural customers typically do not cover the costs of universally connecting them.[10]

However, there are several challenges with subsidies:

- The sustainability and effectiveness of subsidies in achieving universal access to electricity are inadequate (due to the budget constraints and shifting priorities stated above).
- There is inequity between the heavily subsidized national grid (transmission and distribution) and the mini-grid.
- Subsidies do not always target the intended audience. Instead of benefiting the most vulnerable customer groups, all customers benefit, limiting its effectiveness.
- Challenges of results-based financing such as accountability and independent results verification of outcomes of connection subsidies.

COUNTRY STATUS

The countries examined here have both CAPEX and OPEX subsidies. In addition to the objective of promoting universal access to electricity, the additional objectives for subsidies include: 1) increase access/influence in siting mini-grids in unelectrified areas, 2) improve the availability of the service in underserved areas, 3) allow private operators to run sustainable businesses by being profitable within a reasonable margin, 4) lower the tariff paid by mini-grid

[10] What's the Problem with Subsidizing Private-Sector Rural Electrification? Greentech Media, February 2019

utility customers and bring that tariff closer to the national average tariff paid by the grid-connected customers, and 5) keep the micro-utility in business to continue providing service.

TABLE 4.7: SUBSIDY AND GOVERNMENT INCENTIVES TYPE, OBJECTIVES AND WHO PAYS

SUBSIDY AND GOVERNMENT INCENTIVES TYPE, OBJECTIVES, AND WHO PAYS

SUBSIDY AND INCENTIVES	EXAMPLES	WHO PAYS	OBJECTIVES
CAPEX Subsidies and Incentives	CAPEX (e.g., in India, up to 90% of CAPEX)	Private owned – Donors Public owned – Governments, Rural Electrification Funds (REF), Donors, Faith-based/owned organizations	• Increase access/influence mini-grid siting in areas not electrified. • Improve the availability of the service in underserved areas. • Allow the private operators to run sustainable businesses by being profitable within a reasonable profit margin. • Lower the tariff paid by the mini-grid utility's customers and bring that tariff closer to the national average tariff paid by the grid-connected customers. • Keep the micro-utility in business to continue providing service.
Increasing productive use of electricity.	CAPEX import duties and VAT remissions by governments	Governments	
	Results-based financing (RBF) -per connection subsidy	Donors	
	RBF - per kWh subsidy	Donors	
OPEX Subsidies and Incentives	OPEX subsidies provided included indirect technical assistance	Donors	
	Harmonized tariffs where the micro-utility gets the difference between the uniform tariff and its approved tariff or LCOE	Inter-customer cross-subsidies tariff harmonization funds, corporates like in India	
	Top up to pay specific OPEX like in Zambia where the REA pays the salaries of the mini-grid employees of a REA-owned mini-grid that is operated by the community	REA – **Zambia** Government's Rural Electrification Authority	

In addition to the above, the AMDA is actively proposing a new $300million RBF fund that will provide guarantee funds to cover foreign exchange and political risks.

The table below includes questions used to assess the practical implementation of mini-grid subsidies to gain insight into subsidy strategies being used to target low income customers and mini-grid developers.

TABLE 4.8 : STATUS OF SUBSIDIES AND GOVERNMENT INCENTIVES IN FOCUS COUNTRIES

STATUS OF SUBSIDIES AND GOVERNMENT INCENTIVES IN FOCUS COUNTRIES

QUESTION	COUNTRIES STATUS
Did the mini-grid receive subsidies/are incentives available to mini-grid operators?	Varying subsidies/incentives are available to mini-grid developers in all countries. Sources of subsidies are governments, donor/development partners in the form of grants, concessionary terms loans and guarantees.
Are the incentives designed to end on a given date?	Donor-funded incentive programs tend to be designed to end by a certain date, by which time funds are exhausted and/or certain targets achieved. Government programs such as tax incentives are specific, e.g., an import tax exemption for capital equipment. By contrast, a tariff harmonization subsidy is a recurrent subsidy from/by publicly owned and operated mini-grid, that currently have no end now, but that might change.
Does the recipient of the incentive depend on periodic government or international donor funding to maintain solvency?	The results are mixed. Because the industry is nascent, it is too early to tell.
Is there a rural electrification fund (REF) and how are resources raised?	Most countries have a REF, which is generally funded from a levy on national utility customers, government budget allocations, and specific targeted international development partners, including the World Bank. Those countries that currently do not have a REF indicated that there are plans to have an REF in the future. But this REF is only accessible to the government entities/program, not to private mini-grids (except in **Cambodia**).
How is the benefit of the incentive program quantified (e.g., # of connections made, kWh generated)?	Success is measured in various ways: • Number of connections. • Increase in access to electricity/electrification rate. • Some are country or program-specific while others are anchored in the SE4ALL/SDG7 goals.
Are there direct subsidy or cross-subsidy schemes in place to be an additional revenue stream for mini-grid operators?	Direct revenue subsidies or cross-subsidies exist in some countries, but not in others. Tariff bonuses and harmonized national tariff subsidies are also a form of revenue subsidy for compensation when the grid arrives.
Are micro-utilities able to access the same subsidy or government bailout programs as national utility companies?	Privately owned mini-grids generally cannot access the same government subsidies as national utility companies.
How much is allocated to each subsidy program?	Government subsidies to the national utility and/or rural electrification authorities vary from budget year to budget year. Subsidies from development partners vary with funders' priorities and eligibility as provided by the program.

LESSONS LEARNED

Subsidies/grants for mini-grids deployment continue to be a primary point of discussion. There is as much participation by the public sector as the private sector in mini-grid deployment. But the private sector's access to subsidies is not so straightforward. Access to subsidies is skewed in favor of government/public utility and public utility owned mini-grids. There is a general attitude that it is fine for publicly-owned utility/government entities and NGOs to receive subsidies as a public entity is associated with providing a public good. On the other hand, the perception is that privately owned mini-grids are for the pursuit of profits for their investors and therefore do not deserve subsidies. Yet, in the mini-grid space, they are offering the same service to the same rural community: increasing universal access to electricity. Policymakers should therefore be cognizant that:

- A subsidy only goes through a private mini-grid entity to the community in the form of connection charges and/or lower tariffs. It is not primarily for the benefit of the private mini-grid.
- A subsidy enables the private mini-grid company to go where it can have an impact and make money, so governments need to agree to this.
- Results-based financing will be an effective way of blending private capital with non-commercial funding/subsidies.
- Today, subsidies are required to reach scale, but may not be required forever. The amount of subsidy required will further reduce as off-grid technology costs decrease with scale.

Subsidies are one intervention that policymakers use to achieve some of the public interest objectives stated above. Where the private sector is required to play a role towards achieving these objectives, the same subsidies provided to the public utilities/ mini-grids should be extended to the private sector to encourage rapid deployments at scale towards increasing universal access to electricity.

GUIDELINES – SUBSIDIES AND GOVERNMENT INCENTIVES

- Mini-grids, like all prior rural electrification programs, will require government incentives and subsidies from other sources for capital and operating expenditure (CAPEX and OPEX).
- Subsidies and government incentives should be accessible to both public and private sector entities delivering rural electrification (grid expansion or mini-grid).
- Subsidies and government incentives extended to the private sector should be awarded via a competitive (tender and/or auction) process in line with the country's public procurement regulations to ensure transparency and value for money to the public.
- There should be clear accountability and independent results verifications of the outcomes of the subsidies and government incentives for them to be accessed by the private sector
- The objectives of subsidies and government incentives should be clear
- The subsidies and government incentives should be targeted, reduce over time and be time-limited with an endpoint, upon which they are to be replaced by electricity productive uses and social enterprises that can lift the communities out of poverty.
- Government incentives should not be about government paying private sector, but it should be about equity, to treat all sources of energy systems the same (i.e., energy technology neutrality in incentive dispersal) and bring the mini grid costs down to parity with grid supplied energy costs. Such government incentives could consider extending to giving land free for mini grid deployment, free distribution, free connection.

5. MINI-GRID INTERCONNECTION TERMS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When the grid enters a mini-grid's service territory, the mini-grid owner may decide that it is profitable to interconnect with the grid. Interconnection requires compliance with the country's grid code, which outlines numerous standards and regulations for interconnecting generators or distribution companies. The grid code will also outline the process of applying to the utility for interconnection. However, these rules, regulations, and standards are frequently onerous or inappropriate for mini-grid applicants. This section examines the different options available to regulators and grid code developers for modifying grid codes to be more accommodating to mini-grid interconnection. It also looks at the challenges these options create and discusses ways other countries have addressed these challenges. Last, this section presents several guidelines for improving interconnection.

There are many technical and regulatory options for mini-grid interconnection with utility-owned distribution lines. Four primary issues are examined here that should be addressed when electricity regulators want to create regulations that promote mini-grid interconnection:

1. It is not economically viable for mini-grid developers to comply with the same standards as large-scale, interconnected generators.
2. Mini-grid developers are extremely cost sensitive and requiring compliance with the grid code at mini-grid commissioning can add significant CAPEX and slow the pace of mini-grid deployment.
3. Mini-grid developers cannot absorb the same costs or delays that are tolerated by large-scale generation developers.
4. The cost of applying for interconnection can be difficult for mini-grid developers to control or predict, adding uncertainty to their cost-benefit analysis.

Each of these four issues poses an overarching question that can be answered by several options that regulators can pursue, each with its own challenges. As a result, different countries have different answers for these four issues. The report examined the current status of each interconnection

issue within each case study country and other countries examined in the literature (see Table 2 1). This section presents each interconnection issue; the options regulators can choose to implement; the challenges for each option; the current status and best practice of countries' approach to answering interconnection issues; and guidelines gleaned from best practice.

5.1 STANDARDS FOR MINI-GRIDS INTERCONNECTING WITH THE GRID

There is a plethora of standards associated with electrical generation and distribution equipment, the design and construction process, and testing and commissioning. Their aim is to provide a common understanding of how equipment and processes should work across different organizations and geographies. This interoperability across organizations and geographies allows mini-grid developers and operators to design, install, and maintain their mini-grids more cheaply by allowing them to utilize standardized designs and spare parts across multiple countries. Regulators must balance interoperability with country-specific conditions that necessitate the development of unique standards. The more national standards deviate from regional or international standards, the more costly it will be for mini-grid developers to deploy mini-grids in a particular country

For simplicity, the SURE team has limited the scope of this section to:

- **Equipment standards** – equipment standards outline the tests and functions a specific piece of equipment must pass or possess.
- **Functionality standards** – functionality standards outline the use of technology and can be grouped into several general categories: planning and design, generation, storage, communication, management, and measurement, conversion, and consumption.[11]
- **Power quality standards** – these standards are set by the regulator and dictate the allowable voltage, frequency, harmonic distortion, and generator disconnection and reconnection parameters for all parties interacting with the grid.
- **Service quality standards** – Service quality standards set minimum required generator availability and reliability parameters as well as capacity requirements for connections.

Table 5.1 shows the mini-grid standards options and challenges that regulators can pursue. It is important to convey that a regulator should never omit safety standards from its mini-grid interconnection standards, even if it decides to omit all other standards requirements for mini-grids.

TABLE 5.1: STANDARDS OPTIONS AND CHALLENGES

STANDARDS OPTIONS AND CHALLENGES

REGULATOR OPTIONS	OPTION CHALLENGES
1. Do not set standards (except minimum safety standards)	Without technology or equipment standards, low-quality equipment can cause system failures, lower service quality, and present health and safety risks. They can also give mini-grid service a bad name. The lack of power quality standards may damage upstream (utility company) or downstream (end-user) equipment and/or result in low-quality services that alienate customers.
2. Require all mini-grids to adhere to utility grid standards	Gaps in national grid standards may not adequately address every mini-grid technology, leading to regulatory gray areas for some mini-grid developers. Complying with national grid standards may be too expensive for some smaller mini-grid projects (micro-grid) and may hinder innovation or adaptation to local conditions.
3. Develop mini-grid specific standards	Significant time and effort from regulators are required to develop new mini-grid specific standards.

[11] IRENA, "IRENA innovation outlook: Renewable mini-grids," Abu Dhabi, 2016

CURRENT STATUS AND BEST PRACTICE

The adaptation of international standards into country or region-specific standards is common for most of the countries examined. Standards created by the International Electrotechnical Commission (IEC), the Institute of Electrical and Electronics Engineers (IEEE), the Underwriters Laboratories, and the American Society of Testing and Materials are commonly used to fill in gaps found in national or regional standards. The adaptation of international standards is also commonly adapted to national grid codes, e.g., Rwanda has adapted IEC 60071 to dictate permissible transient voltages on its distribution system.[12] All countries expect that mini-grids to be interconnected to the grid must comply with power quality requirements as dictated by the national grid code.

Rwanda's grid code does contain language that allows the regulator to apply exemptions to off-grid networks and off-grid networks that are subsequently interconnected with the grid. However, mini-grids with exemptions are expected to comply with the grid code within an "appropriate time limit."[13]

The application of technological, availability and reliability standards and other regulatory aspects of mini-grids in Zambia is dependent on generation technology, generation capacity, and the cluster (type of mini-grid category) that Zambian regulations assigns to mini-grids. In general, small PV, wind, and biogas-powered mini-grids between 10 and 100 kW need not meet the same stringent technical standards that large generators are held to. PV, wind, and biogas-powered mini-grids under 10 kW are not expected to be connected to the Zambian grid and are exempted from most standards requirements.[14] A description of each of the three Zambian mini-grid clusters can be found in Zambian mini-grid regulations and explicitly state that mini-grid developers can use accepted international recommendations, codes, and standards in the absence of a comparable national standard.

TABLE 5.2: ZAMBIAN CLUSTERS

ZAMBIAN CLUSTERS[15]

CLUSTER 1	CLUSTER 2	CLUSTER 3
All hydro-powered mini-grids	PV, wind, or biogas-powered mini-grids larger than 10 kW	PV, wind, or biogas-powered mini-grids equal to or smaller than 10 kW

Unintentional islanding is a dangerous situation that can damage utility equipment and be a safety hazard for employees repairing utility lines. All the countries reviewed have technical requirements that prohibit unintentional islanding. However, intentional islanding can be a critical component of both the SPP+SPD and SPD with backup generation business models. Tanzania's grid code allows intentional islanding if equipment complies with standards on the transition from grid-connected to islanding mode, maintaining power quality and availability requirements, and resynchronizing with the grid.[16]

5.2 WHEN MINI-GRIDS SHOULD BECOME GRID-COMPLIANT

Many mini-grids were never designed to comply with their host country's grid code despite the presence of a grid code that requires compliance. Cambodia has hosted many non-compliant diesel-powered mini-grids before the Electric Authority of Cambodia adopted a new grid code that incentivized mini-grids to upgrade to code compliance and transition to small power distributors.[17, 18] Grid code compliance increases capital and operation costs in a market that is cost sensitive and financially starved. Developers may choose to avoid these costs by designing a non-compliant mini-grid, and this may have little effect on their bottom line if the grid never arrives within their catchment area or arrives late in the mini-grid's life. The options and challenges for when a mini-grid should become grid compliant are shown in Table 5 3.

[12] Rwanda Utilities Regulatory Authority, "Rwanda Grid Code," Rwanda Utilities Regulatory Authority, Kigali, 2013
[13] ibid.
[14] Energy Regulation Board, "Technical Requirements for Mini-Grids in Zambia," Energy Regulation Board, Lusaka, 2018
[15] Ibid.
[16] P. Kruangpradit, "Tanesco Grid Code for Embedded Generation: Technical Assistance to Tanesco in Formation of SPP Cell," The World Bank, 2012
[17] C. Greacen, R. Engel and T. Quetchenbach, A Guidebook on Grid Interconnection and Islanded Operation of Mini-Grid Power Systems Up to 200 kW, Berkeley, CA: Lawrence Berkeley National Laboratory and Schatz Energy Research Center, 2013
[18] B. Tenenbaum, C. Greacen and D. Vaghela, "Mini-grids and the Arrival of the Main Grid: Lessons from Cambodia, Sri Lanka, and Indonesia.," World Bank, Washington, DC, 2018

TABLE 5.3: READINESS OPTIONS AND CHALLENGES

READINESS OPTIONS AND CHALLENGES

REGULATOR OPTIONS	OPTION CHALLENGES
1. Do not require the mini-grid to be grid compliant.	If mini-grids are not required to be grid compliant, interconnections between the mini-grid and main grid may be more difficult, more expensive, or less likely to happen. Mini-grid customers may not get the same electricity availability and power quality as those on the national grid.
2. Require the mini-grid to be grid code compliant at project commissioning.	Requiring all mini-grids to be grid compliant at commissioning requires larger up-front investments from developers that will be a barrier to smaller-scale projects. Stringent standards may slow down innovation in a country's mini-grid sector, resulting in lower/slower penetration of the mini-grid in off-grid areas.
3. Require the mini-grid to be grid code compliant at interconnection.	Requiring all mini-grids to be grid compliant at the time of interconnection implies a period of time when mini-grids will not comply with the grid code and can result in different levels of service for mini-grid ratepayers between utility-served ratepayers. Mini-grid owners may never bring their mini-grid into grid compliance.
4. Develop different grid compliance timing requirements based on project classes or categories.	Basing grid compliance timing requirements on project classes creates a more complicated regulatory environment that can confuse potential developers and slow both project development and interconnection application processing time.

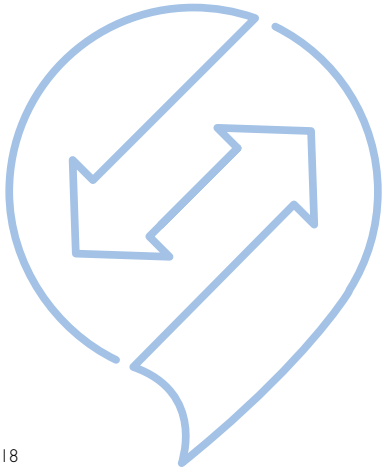
CURRENT STATUS AND BEST PRACTICE

Several countries, such as Cambodia, Ethiopia and the DRC, require mini-grids to be grid code compliant upon project commissioning.

Zambia has different deadlines for grid-readiness based on a mini-grid's generator capacity and assigned cluster. All Cluster 1 mini-grids and Cluster 2 mini-grids with generation capacities over 100 kW are expected to be grid-ready at project commissioning. Cluster 2 mini-grids with less than 100 kW of generation capacity are expected to upgrade their grid to become code compliant within 24 months of the grid encroaching on the mini-grid licensed area. Cluster 3 mini-grids are not expected to connect to the grid and therefore do not need to be grid compliant.[19]

5.3 HOW A MINI-GRID APPLIES FOR INTERCONNECTION

National grid codes will dictate the process by which mini-grids, or any other embedded generators, can apply for a permit or license to interconnect with a utility grid. This process usually starts with a letter of intent, which usually includes several elements such as: negotiating a power purchase agreement (PPA), conducting studies on the effects of interconnection on the grid, paying for grid upgrades, and commissioning and testing. Complying with the interconnection process can be costly in relation to the cost of a small mini-grid. Uncertain processes that have many gatekeepers with the power to block an application can stifle private investment into mini-grids.



[19] Energy Regulation Board, "Technical Requirements for Mini-Grids in Zambia," Energy Regulation Board, Lusaka, 2018

TABLE 5.4: APPLICATION PROCESS OPTIONS AND CHALLENGES

APPLICATION PROCESS OPTIONS AND CHALLENGES

REGULATOR OPTIONS	OPTION CHALLENGES
1. Do not allow (or dictate) a mechanism for the mini-grid to apply for interconnection.	Not allowing SPPs to apply for interconnection prevents private participation in the country's rural electrification strategy.
2. Allow the mini-grid to follow an interconnection process created for embedded generators.	An embedded generator interconnection process may not be cost effective for the current generation of private, small-scale, renewable energy-based mini-grids.
3. Create a mini-grid-specific interconnection process.	Creating mini-grid-specific interconnection rules results in extra effort for regulators. In the absence of a standardized interconnection process, utilities may propose costly and time-consuming interconnection studies in the absence of regulations.

CURRENT STATUS AND BEST PRACTICE

Tunisia's electricity sector is not liberalized, and private companies cannot obtain licenses to generate or distribute electricity. In addition, monetary regulations prohibit foreign, private investment in the electricity sector. The electrification rate is currently 98%, with off-grid customers limited to remote, rural areas. Electrification is carried out by the state-owned utility, which prioritizes grid extension over mini-grid deployment.

Grid code regulatory authority in India is delegated to each state. As a result, the interconnection application process varies from state to state. Applying for interconnection in multiple Indian states requires complying with multiple, dissimilar application processes that are not optimized for approving small mini-grid interconnections with the grid. This increases costs for mini-grid developers who wish to interconnect with the grid. A summary of problems that mini-grid developers face when trying to apply for grid interconnection in India includes:[20]

- **High Number of Authorities Required for Approval:** Developers seeking interconnection approval are required to interact with many state and national bodies, each with its own delays that contribute to a long approval process.
- **No Deadlines for Authorities to Provide Approval:** Most states do not have a mechanism to limit how long an approving authority can take to process a step in the approval process. This creates uncertainty for developers who want to know when to expect interconnection approval.
- **Unharmonized Application of Rules:** Organizations that are required to approve interconnection applications apply rules differently. This is particularly true if approval is required from both national and state organizations. This leads to developers having to comply with the most complicated combination of approval requirements.
- **Poorly Adapted Process:** It is common for the interconnection approval process in India to be designed to address all possible generation technologies, but that results in an ungainly process that requires all applications to obtain approval from the Civil Aviation Department, even though applications for solar or biogas generation do not pose a danger to civil aviation.
- **Same Process for All Sizes:** Many states in India do not have different application processes for large and small interconnections. This creates a significant burden on small capacity mini-grids, which must comply with a process designed to interconnect large renewable (and non-renewable) generators.

Tanzania has a fast-track screening process for small embedded generators, including mini-grids, which reduces the engineering assessment requirements that applicants installing less than 1 MW must fulfill. For generators under 250 kW that connect to a low-voltage feeder, the engineering assessment is omitted except for verifying the thermal overload of all equipment.[21] Rwanda also exempts

[20] J.-B. Spitzley, R. Bruckmann and M. Eichelbronner, "Report on Indian Circumstances for the Promotion and Development of Solar Installation Compared to International Standards and Lessons Learned," GIZ, Berlin/Mannheim, 2015

[21] P. Kruangpradit, "Tanesco Grid Code for Embedded Generation: Technical Assistance to TANESCO in Formation of SPP Cell," The World Bank, 2012

generators smaller than 250 kW from the same connection requirements as larger generators.[22] Zambia has taken this a step further by creating different procedural requirements for mini-grid that are less than 1000 kW, less than 100 kW, less than 10 kW, and less than 2 kW.[23]

Unlike India, Tanzania requires utilities and other authorities to approve or reject applications within a specified timeframe.[24]

Most power purchase agreements between utilities and renewable energy SPP and mini-grids require the utility to buy all the power generated by the SPP or mini-grid. No utility reviewed for this project required applicants to install equipment that would enable the utility to control mini-grid generation during periods of feeder congestion or grid instability, but this may become common as renewable energy penetration on the grid increases. Many grid codes maintain stability by limiting an applicant's renewable export capacity to below a fixed fraction of the feeder's or transformer's capacity rating.

5.4 WHO PAYS FOR GRID UPGRADE TO INTERCONNECT THE MINI-GRID

Traditionally, interconnection applicants have paid for equipment that is added on their side of the point of supply (POS) and the costs the utility incurs to process the interconnection application. However, utilities that oppose mini-grid interconnection, but are required to comply with regulations that allow for mini-grid interconnection, can use exorbitant pay structures to dissuade the submission of interconnection applications.

TABLE 5 5: COSTING OPTIONS AND CHALLENGES

COSTING OPTIONS AND CHALLENGES

REGULATOR OPTIONS	OPTION CHALLENGES
1. Charge mini-grid developers for equipment costs up to the POS.	Utility costs to upgrade lines after POS will subsequently increase tariffs for rate payers. mini-grid projects may be delayed if utility does not make necessary changes to distribution system on time.
2. Charge mini-grid developers for all upgrades to the distribution system associated with interconnection.	May inhibit the development of mini-grids or their interconnecting to the grid. May disincentivize utilities from upgrading the distribution system in areas where they expect SPPs to pay for upgrades.

CURRENT STATUS AND BEST PRACTICE

All countries agree that the mini-grid developer is responsible for paying for new hardware and upgrades on their side of the POS.

Tanzania gives developers the option to pay for and implement changes to the grid above the POS to reduce potential delays.[25] These changes must comply with the utility's standards and work is overseen by the utility.

Both Senegal and Zambia use the ideas of licensed consignment zones to demarcate exclusive areas for specific developers. Mini-grid developers can apply for these consignment licenses. Under Zambian regulations, if another entity encroaches on a mini-grid that is smaller than 100 kW, the encroacher must pay for interconnection and grid code compliance upgrades for the licensee.[26]

[22] Rwanda Utilities Regulatory Authority, "Rwanda Grid Code," Rwanda Utilities Regulatory Authority, Kigali, 2013
[23] Energy Regulation Board, "Technical Requirements for Mini-Grids in Zambia," Energy Regulation Board, Lusaka, 2018
[24] P. Kruangpradit, "TANESCO Grid Code for Embedded Generation: Technical Assistance to TANESCO in Formation of SPP Cell," The World Bank, 2012
[25] P. Kruangpradit, "TANESCO Grid Code for Embedded Generation: Technical Assistance to TANESCO in Formation of SPP Cell," The World Bank, 2012
[26] Energy Regulation Board, "Technical Requirements for Mini-Grids in Zambia," Energy Regulation Board, Lusaka, 2018

GUIDELINES – MINI-GRID INTERCONNECTION REGULATIONS

Policy and regulations should allow an ownership model that protects property rights. Those property rights should be reflected in provisions for willing-buyer-willing-seller with commensurate compensation (i.e., should not be confiscatory) and based on best practices in the mini-grid sector.

1. Define the process for applying for interconnection.
2. Identify who is responsible for the required analyses and systems upgrades.
3. Outline safety and protection requirements.
4. Outline the required interconnection testing and the commissioning process.
5. List any required communication and data exchange requirements between the utility and the regulator

In most cases, the interconnection of mini-grids can be effectively addressed by current grid codes if the grid codes are updated to accommodate new generation technologies and effective regulation for smaller generators. The important guidelines include:

Larger mini-grids should be compatible with the grid, but requirements should vary with mini-grid size.
Interconnection requires compliance with the grid code, which should outline compliance with equipment, functionality, power quality, and service standards. Compliance with the grid code adds cost to a mini-grid project and these costs do not vary with mini-grid size unless the requirements for smaller systems are less stringent. Small-scale mini-grids can be a cost-effective technological answer to off-grid electrification, but if they have to comply with the same regulations as large hydroelectric power stations, investors will hesitate to finance beneficial projects. Three countries – Zambia, Tanzania, and Rwanda – have differentiated regulatory tiers. Observed cut-offs for tiers include: 1 MW, 250 kW, 100 kW, 10 kW, and 2 kW. Even if regulators choose to reduce or eliminate interconnection requirements for smaller mini-grid tiers, all interconnection applicants should comply with basic safety standards.

Regulations should be based on national or regional standards that minimize country-specific compliance costs for mini-grid developers and operators.
Many countries adapt international standards like IEEE 1547 or regional AFSEC standards to be the basis for their grid code. Such standards address the requirements for the performance, operation, testing, safety and maintenance of the inter-connection. Mini-grid developers should be allowed to use an applicable international standard, if mini-grid interconnection regulation or the grid code omits guidance. Developing country-specific standards that significantly differ from international practice will increase mini-grid developer compliance cost and can slow in-country mini-grid deployment. Some mini-grid developers operate internationally and have already created mini-grid designs that comply with international standards. Creating new designs that comply with country-specific standards is an additional cost that may deter investment or will be passed on to ratepayers.

Intentional islanding of a mini-grid should be allowable if international standards are followed.
Unintentional islanding from the grid is a safety issue and should be prohibited, but intentional islanding can be a key value proposition for some mini-grids. In some cases, mini-grids can provide better quality electricity and availability to their customers than the utility can, but only if they can periodically disconnect from the grid.

GUIDELINES – MINI-GRID INTERCONNECTION REGULATIONS (CONTINUED)

Grid codes should allow mini-grids to intentionally island if they comply with IEEE 1547.4-2011 or a similar standard. Even while in islanded mode, mini-grids Should be held to the same power quality and availability requirements as when they are connected to the grid. Accommodating intentional islanding may require additional analysis during the application process and a change to anti-islanding tests conducted during the interconnection testing.

The application approval process for interconnection should be straightforward and appropriate.
The interconnection approval process should streamline approval from a limited number of authorities, include harmonized application of rules between approving authorities as necessary, include clear deadlines for both the developer and approving authorities, and be appropriate for the size of the mini-grid applying for interconnection. This will balance the utility's need for information and the mini-grid developer's need for an approval process that is predictable in cost and duration.

Ensure that interconnection application costs and duration are predictable for the applicant.
Processing interconnection applications costs utilities time and money. These costs can include distribution system upgrade costs, analysis or administration costs, and/or commissioning costs. It is common, and appropriate, for utilities to be reimbursed for some of these costs by applicants. However, high or unpredictable application costs and delays can be used by utilities as a tool to deter developers from applying for interconnection. Utilities should be encouraged to create a formal, standardized table for hardware, analysis, administration, and commissioning costs so that developers can anticipate what payments must be made to the utility company. Regulations should allow mini-grid developers to hire third parties to conduct required grid analyses on the effects of interconnection for subsequent utility review.

Mini-grid interconnection applications should also only be responsible for paying for equipment up to their POS; utilities should be responsible for upgrades beyond the point of supply. The cost of upgrading the distribution grid to accommodate proposed interconnection should be spread to all ratepayers at the subsequent tariff review. In order to address the possibility of delays in upgrading the utility's distribution system to accommodate the mini-grid interconnection, mini-grid developers should have the option to upgrade the grid beyond the POS, provided upgrades are done according to utility standards.

A process should be in place to resolve disputes between the utility and applicant.
Interpretation of the grid code may not be the same and a third party should be available to provide a neutral interpretation to the utilities and mini-grid developers.

Grid stability analyses should be required as part of the interconnection application process for applicant with variable renewable energy generation.
Variable renewable energy (VRE), like solar and wind, can rapidly and unpredictably change production requiring other generation sources on the grid to ramp up or ramp down their own production. Sudden changes in VRE generation can threaten the stability of the feeder line a mini-grid is connected to. In addition, the power flow reversal in a transformer or substation can damage utility equipment. To prevent these outcomes, all regulators should ensure that a stability analysis is part of the interconnection process of a mini-grid that utilized VRE. Some regulators and utilities also impose limits on how much mini-grid generation capacity (both VRE and non-VRE) can be installed on a single feeder or circuit.

6. MINI-GRID COMPENSATION MECHANISMS

Photo: © AdobeStock.

The potential encroachment of the national grid into areas served by mini-grids is a major risk for mini-grid investors. Mini-grid permits and licenses should provide adequate legal protection for private investors and appropriate financial compensation mechanisms should be in place for mini-grid owners. Countries should compensate owners for the cost of privately financed assets and any lost revenues, allowing them to make a fair return on their investment.

Some governments provide guidance on how mini-grids might eventually be integrated into the national grid through several specified commercial models, some of which are outlined here:

- **Distributor model** – The mini-grid buys wholesale electricity from the national grid and supplies retail electricity to local customers. In such cases, the mini-grid operator can:
  - Continue to operate the generation equipment and supplement demand from the grid—this is the case of Tanzania where well-define net-metering exists, or
  - Move the generation equipment to a different location
- **Generator model** – The mini-grid sells electricity to the national grid or another off-taker but stops selling to local customers. Instead, it sells the distribution assets to the national grid or another public entity.
- **Distributor/generator model** – The mini-grid converts from an isolated mini-grid to an operator of a distribution network integrated with the national grid. It buys wholesale electricity from the national grid and supplies retail electricity to local customers. It maintains the existing generator and may add a few new ones and provides backup for the main grid and retail customers.
- **Buyout model** – The developer sells either the whole mini-grid (both distribution and generation) or just the distribution portion, transferring the generation equipment to another site.

Irrespective of the compensation model, one of the key requirements for the effectiveness of compensation mechanisms is to ensure the mini-grid network is compliant with the distribution network operator's requirements.

CHALLENGES

- The lack of certainty on compensation when the national grid encroaches into a mini-grid's service territory.
- Lack of an implementable valuation model to determine the amount of compensation when the national grid arrives.
- It is not clear where the money will come from to pay the compensation given the national utilities' weak balance sheets.

COUNTRY STATUS

Except for India and DRC, all the reference and case study countries have regulations that are either in place or in draft form. These regulations provide for compensation mechanisms and clarify how a private investor should be compensated when the main grid arrives at a mini-grid service territory.

Has the government identified mini-grid service territories to distinguish areas in which the government or utility plans to extend the grid?
In most cases, the governments designate service territories in terms of plans for grid extension (green field) and areas

TABLE 6.1: METHODS FOR DEMARCATING MINI-GRID SERVICE TERRITORIES

METHODS FOR DEMARCATING MINI-GRID SERVICE TERRITORIES

COUNTRY	HOW A MINI-GRID SERVICE TERRITORY IS DEMARCATED
Cambodia	The allocation seems to be opportunistic and business oriented rather than government controlled. The government intervenes while approving the technical standards and tariffs in order to grant licenses.
India	Due to the lack of clarity around the Indian government's grid extension plans, off-grid electrification enterprises look only to operate in remote off-grid regions with a low probability of grid extension.
Ethiopia	The National Electrification Plan states Ethiopia's plans to scale up public sector-led off-grid programs, which include mini-grids for remote areas which the grid will not reach in the near term.
Kenya	Under the Kenya National Electrification Strategy (KNES), the Government has mapped out areas/territories that will be supplied by mini-grids. For areas with proximity to the national grid, the KNES proposes a 15 km buffer.
Nigeria	Distribution companies and mini-grids are responsible for expanding the medium-voltage system. Distribution companies plan grid expansion in their area. Nigeria's regulations allow registered mini-grids to choose a site but restrict the location possibilities. Developers applying for a permit must install their systems in unserved and underserved areas.
Zambia	The new regulations are still being road tested and hence have not been finalized. One aspect being tested is the competitive process of assigning service areas.
Rwanda	"…. an ongoing consultancy commissioned by the utility's development arm, Energy Development Corporation Limited (EDCL), and funded by the African Development Bank-hosted Sustainable Energy Fund for Africa (SEFA), has identified over 200 villages as potentially feasible sites for mini-grids and will eventually provide advanced feasibility studies for up to 20 sites."[27]
Senegal	A thorough planning exercise is still needed for a clear demarcation of off-grid sites. Outside the four (of ten) concessions allocated to SENELEC, the rural electrification agency ASER has the mandate to develop rural electrification programs and projects, as well as select private utilities to build and operate off-grid assets.
DRC	The Green Mini-Grid Market Development Programme's Mini-Grid Market Opportunity Assessment defines grid and off-grid areas based on their distance from the power network. Grid regions are defined as being the areas within 15 km of the grid. The main off-grid population centers were then mapped, enabling an analysis of the potential for mini-grid projects.

[27] Provision of Services for Feasibility Study and Rollout Plan for Mini Grid Sites in Rwanda. Project Reference Number: 11.07.023/1402/19/ EDCL-MD/rjg/eb

with proximity to the national grid, e.g., a 15 km buffer (brown field). However, some governments do not have such demarcations.

Does the Ministry of Energy or utility regulator have a national electrification policy and regulations that clarify how a private investor should be compensated when the main grid arrives at a mini-grid service territory?

- Senegal provides for assets transfer, but under the current dispensation, compensation is not mandatory although it is hoped the regulations currently under development will correct for this.
- Compensation has not been applied, even in countries with a compensation policy in the regulations.

What are the eligibility criterion for compensation?

- For those countries with a compensation policy, the eligibility criterion is to have a permit/license and the mini-grid must be built in compliance with the technical standards of that country.

Which options are given to a micro-utility when the main/regional grid encroaches on the micro-utility's service territory?

- Tanzania has a comprehensive list of options available for micro-utilities in the event of grid encroachment. They are described below.
- Countries without a compensation policy do not have these options; Senegal's current provisions seem to be confiscatory.

When the grid has extended to a mini-grid service territory and mini-grid operators sell their assets to the utility, is there a process in place for valuing the mini-grid developer's assets before selling? For example, when assets are transferred to the utility company, is the financial compensation equivalent to the remaining depreciated value of the assets?

- Only Nigeria, Kenya, Tanzania and Rwanda specify a methodology for valuing the assets to be transferred.
- Kenya's draft mini-grid regulations and Nigeria's methodology seem to be similar based on depreciated historical cost plus a revenue foregone top-up.

TABLE 6.2 : TANZANIA REGULATORY OPTIONS FOR MINI-GRID COMPENSATION

TANZANIA REGULATORY OPTIONS OF MINI-GRID COMPENSATION

OPTION	DESCRIPTION	COMPENSATION METHOD
Case 1	Continuity in the mini-grid's operation, as a viable and sustainable option without interconnection with the national grid.	No compensation.
Case 2	Continuity in operation of the mini-grid, with interconnection to the national grid.	No compensation.
Case 3	Continuity in operation of the mini-grid's generation as a power supplier, but sale of the mini-grid distribution network to the national grid operator.	Compensation for the asset value of the distribution system.
Case 4	Sale of generation assets and distribution system, both to the national grid operator.	Compensation for the asset value of the generation and distribution system.
Case 5	Sale of the distribution system to the national grid operator and removal of the generation system by the mini-grid operator for use elsewhere.	Compensation for the asset value of the distribution system only.
Case 6	Removal of both the generation and distribution mini-grid assets by the mini- grid operator for use elsewhere.	No compensation.
Case 7	Franchise model: Like Case 4, continuity in the mini-grid's operation, with interconnection to the national grid, but as a franchisee.	Compensation for the asset value of the generation and distribution system.

- Tanzania's valuation methodology is based on an accounting depreciated net book value.
- No stated methodology is used in Senegal or Rwanda.
- None of these countries has applied their respective methodologies in practice.

Is there a licensing process in place so mini-grid developers can legally transition into small power producers or distributors?

- In India, no license is required.
- All the countries studied, except Senegal and DRC, have a licensing process in place.

Who pays for mini-grid compensation? How is the amount of compensation assessed?

- In Cambodia, consumers pay through a tariff bonus.
- In the other countries with a compensation mechanism, the utility taking over pays and ultimately the compensation is recovered through a tariff on customers.
- DRC has no compensation policy.

LESSONS LEARNED

Governments should provide guidance on how the mini-grids might eventually be integrated into the national grid. Several commercial models are available to facilitate this integration. Tanzania possesses the longest list of integration and compensation options. But even when compensation policies and regulations exist, this study did not find any country where these have been applied in practice.

When the grid arrives at a mini-grid site, compensation regulations are needed that articulate how private investors can recoup their investment so that private development and investment in mini-grid projects is not stifled. Compensation would be made for the costs of buying out the assets of the mini-grid with commensurate compensation to the investor for those mini-grid assets. Compensation also addresses the loss of a benefit such as exclusivity revenues in the case of abandonment because of the grid's arrival. Depending on country-specific laws and provisions, compensation may be triggered by the expected transfer of some or all the mini-grid's assets when the grid arrives. The assets that mini-grid operators may wish to receive compensation for will depend on the business model and the adaption scenarios.

GUIDELINES – COMPENSATION MECHANISM

- It is important that mini-grid regulations address the anticipated encroachment of the main grid into the mini-grid service territory. The regulations should:
  - Provide guidance on models of how the mini-grids might eventually be integrated into the national grid
  - Provide for certainty in compensation as appropriate
  - Specify the eligibility criteria for such a compensation
  - Specify a credible valuation model for determining amounts eligible for compensation
- Several compensation models can be considered based on best practices and the models for integration of the mini grid into the national grid
- It is important to know where the money will come from to pay the compensation.
  - There is a need to set aside a guarantee fund for compensation. Such a guarantee fund could be financed by donors and governments.
  - The buyout clause needs to be backed by that guarantee fund, and the fund would also provide insurance for foreign exchange and political risks.
- Developing Power Master Plans that clearly define the on- and off-grid territories is important to ensure predictable grid extension. The absence of that, may call for better communication on the expected grid expansion.

GUIDELINES – COMPENSATION MECHANISM ADDITIONAL CONSIDERATIONS

- Compensation could be paid based on the depreciated original installed value of the asset, with this value determined by audited records from the time of the installation. Depreciation would be taken in accordance with regulatory depreciation based on the asset's economic useful life (rather than the shorter accounting depreciation). It is also recommended that the investor be compensated for income shortfalls in the years when the mini-grid is not achieving full utilization (this shortfall is usually recorded in deferral accounts, where a Uniform Systems of Accounts has been implemented).
- Compensation will consider only the contribution of the mini-grid operator to initial and subsequent investment, excluding all grants and subsidies.
- Compensation would be available to a mini-grid operator whose system was constructed to the requirements of the Standards Bureau (or national equivalent).
- For example, the Tanzania Bureau of Standards (TBS) requirements are listed below:
- TBS 01: Standard for Uniform Mini-grid Project Planning
- TBS 02: Standard for Utility Interactive Inverters for Mini-grids
- TBS 03: Standard for Distribution Systems for Mini-grids
- TBS 04: Standard for Wood Poles for Mini-grids
- TBS 05: Standard for Aerial Bundled Cable for Mini-grids
- TBS 06: Standard for Low-Voltage Underground Distribution Systems for Mini-grids
- TBS 07: Standard for Cables for Low-Voltage Underground Distribution for Mini-grids
- TBS 08: Standard for Consumer Electric Metering for Mini-grids
- TBS 09: Grid Interconnection Standard for Mini-grids

7. GENDER INCLUSIVITY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There is increasing evidence that correlates gender diversity in the workforce with improved business performance, including reduced costs (e.g., less absenteeism and turnover); increased productivity, profitability, and engagement; and reduced fraud, among other benefits. While men remain overrepresented in the energy sector, women make important contributions in management and technical positions, including through their work at leading mini-grid companies. The good news is, there is a pool of capable women who have spearheaded innovative business models. However, women-led companies throughout Africa face disproportionately higher barriers in accessing opportunities, including financing.

Governments integrate gender in the energy sector through different channels, including: energy sector policies, poverty reduction policies or strategies, and policies or strategies that support entrepreneurship, local content, and small and medium enterprises. Recent research illustrates the role that gender mainstreaming policies play globally. For example, USAID's Energizing Equality Project identifies trends in cross-cutting gender issues with regional comparisons, while Energia's ten years of work in gender mainstreaming within the energy sector provides many lessons learned. A review of gender mainstreaming in the energy sector more broadly highlights the need for policies to: 1) treat women not only as beneficiaries and vulnerable populations, but as leaders, decision-makers and change agents, and 2) move to practice and action.

Research and policies have largely focused on the energy sector as a whole, with some work exploring gender mainstreaming relevant to mini-grids. This section explores best practices relevant to the mini-grid space in Zambia and Rwanda, as well as Colombia.

Questions used to explore gender mainstreaming best practices:

1. How do your national energy policies, plans and poverty reduction strategies identify clear goals and actions to reduce the gender inequality gap in consumer access to: energy; energy sector workforce; women entrepreneurs; and micro, small and medium enterprise (MSME) owners in the mini-grid industry?
2. What are the unique barriers women entrepreneurs and MSME owners face in securing licenses and permits, formalizing their businesses, and accessing capital and finance in the mini-grid industry in your country? What are solutions to overcoming these barriers?
3. What are the unique barriers that women face in working as employees in the mini-grid companies in traditionally male-dominated roles such as engineers, field technicians, and senior managers? What are some solutions to overcoming these barriers?
4. What are the unique barriers women energy consumers face in accessing on- and off-grid energy, including the ability to afford tariffs and household decision-making power over household spending?
   What are some solutions to overcoming these barriers?

7.1 KEY FINDINGS

There are several commonalities across the three countries examined here:

- All have policies and strategies in place for gender mainstreaming in the energy sector but are at varying stages of developing and implementing specific actions and strategies to improve gender equality and women's empowerment. In addition, most do not embed gender mainstreaming in mini-grid specific policies and strategies, although some countries have begun the process, including our case study countries of Rwanda, Colombia, and Zambia.
- Gender focal points (GFPs) are in place within ministries of energy, which are tasked with developing and implementing gender mainstreaming strategies and plans. There are varying levels of responsibility assigned to GFPs. In some instances there is more accountability at top senior management levels to ensure the implementation of gender action plans.
- While there are varying stages of development of action plans in place to accompany gender policies in the energy sector, resources have not been allocated to implement planned actions.
- These countries are at the beginning stages of planning how to address gender mainstreaming related to mini-grids and renewables.
- There is increasing emphasis on the importance of gender-descriptive and sex-disaggregated data collection, gender analysis, and gender assessments as fundamental to formulating strong evidence-based gender mainstreamed policies and action plans.

7.2 STATUS OF POLICIES AND STRATEGIES

Most countries have national-level gender mainstreaming policies and strategies with a mandate for a national ministry of gender or women to support gender mainstreaming across all sectors. Within the countries studied, all energy ministries have mainstreamed gender within their broad energy policies. Within the last year they have been ramping up efforts to improve and operationalize gender mainstreaming within the sector and

develop strategies and action plans that address gender mainstreaming within the mini-grid value chain.

- The government of **Zambia** adopted an Energy Policy (2008) that is currently under review. As part of the review process, gender experts are engaged in reviewing the policy to strengthen gender mainstreaming. The current policy mentions gender mainstreaming, but in a high-level way that does not address practical implementation. As a result, the Ministry of Energy's (MoE) approach to revising the policy is to include a chapter on gender equality accompanied by practical guidelines for implementation. In 2010 it adopted a Gender Mainstreaming Strategy and Action Plan, supported by the international non-profit organization, Energia. However, there were no resources for implementation, so nothing was done. In response to this, the European Union is now supporting the MoE to develop a new strategy and action plan and have contracted a full-time international gender specialist to work closely with the MoE's GFPs to develop and implement the strategy. Work commenced in early 2019 with an exercise to map the status of gender mainstreaming across various MoE projects. They found that within projects, gender mainstreaming was largely absent, as were sex-disaggregated and gender-descriptive data to support gender mainstreaming. Fundamentally, the MoE recognizes the weakness to date in implementation, and is responding with current plans to: 1) identify the strategic needs of women in the energy sector, particularly in decision-making roles, and 2) develop an empowerment program that supports the sustainable participation of women throughout the male-dominated renewable energy value chain to overcome the current challenge of women often participating as end-users, rather than as operators/sellers.
- In **Rwanda**, the Rwanda Energy Group (REG) has a draft Gender Policy (2019) and plans to identify clear goals and actions to reduce gender inequality. This process began systematically by hiring gender experts who initially conducted gender assessments and gender audits at all levels. This helped to identify the macro picture of gender gaps in the energy sector and at what level mainstreaming gender could practically happen. Specific actions were planned with an accompanying budget. For example, to improve energy access, a gender budget statement was established to support gender equality campaigns and electricity connections for poor female-headed households that were identified during gender audits and assessments. In addition, to solve the problem of a male-dominated energy sector workforce, affirmative action targets were established, including 30% of positions to be occupied by qualified women, accompanied by technical and soft skills trainings to build confidence and resilience. For some entrepreneurs and MSMEs, a private sector gender policy was set, identifying specific working energy groups to support their development.
- **Colombia** has developed a series of policies and regulatory frameworks to protect the rights of women, guarantee the same opportunities and conditions to men, close gender equality gaps, and guarantee equal rights and access to goods and services. Gender equality is a high priority item for the current Duque administration, which created the Presidential Advisory Office for Women's Equity. The National Development Plan 2018-22's "Pact for Colombia, Pact for Equity" aims to boost equality, entrepreneurship and legal enforcement of rights. Cross-cutting areas include environmental sustainability; science, technology and innovation; transport and logistics; digital transformation; public services in water and energy; mining resources; identity and creativity; peace building; ethnic groups; people with disabilities; and equality for women. This plan is consistent with the macroeconomic and fiscal frameworks to guarantee macroeconomic stability and will be financed through a multi-annual investment plan between 2019 and 2022.
- The Ministry of Mines and Energy in Colombia is developing gender mainstreaming guidelines for the mining and energy sectors, beginning with detailing a roadmap for the development of a Gender Equity Policy. In 2019, it is focusing on such labor issues as strengthening labor for the incorporation of women in the industry; harmonizing personal, professional and work life; women's participation in decision-making scenarios in the sector; gender equality culture; and sectoral coordination. To better define each task, the ministry is conducting preliminary assessments of 1) participation in education, employment and promotion

policies, 2) leadership positions, 3) salary gaps, and 4) organizational culture and working environments. In Fall 2019 it will hold regional workshops to collect information for the policy guidelines. Although regional in scope, they will only collect information about labor, rather than for community rural/off-grid. In early December 2019 the ministry will hold an event to launch its first set of guidelines. In 2020, the ministry will focus on community-based solutions and women's engagement (e.g., rural electrification, community-based solutions, female SME owners in rural areas).

7.3 ROLE OF GENDER EXPERTS AND FOCAL POINTS

Most countries have national-level gender mainstreaming policies and strategies with a mandate for a national ministry of gender or women to support gender mainstreaming across all sectors. Within the countries studied, all energy ministries have mainstreamed gender within their broad energy policies. Within the last year they have been ramping up efforts to improve and operationalize gender mainstreaming within the sector and develop strategies and action plans that address gender mainstreaming within the mini-grid value chain.

- In **Zambia**, there are two assigned gender focal points within the MoE: a monitoring and evaluation (M&E) specialist (male) and a senior policy and budget officer (woman). The Ministry of Gender requested that the MoE nominate two staff of the MoE Planning Department as GFPs, due to the department's involvement in budget, planning, policy, and reporting. The MoE oversees the departments of Energy, Petroleum, Finance, HR, and Planning/Administration, and Public Private Initiatives, as well as three institutions, ZESCO, REA and the Energy Board. Projects are generally divided into three sub-sectors: 1) electricity and renewables, primarily managed by ZESCO, 2) renewable energy (mini-grids) and grid extension managed by REA, and 3) petroleum. The MoE, led by its two GFPs, is now creating a gender technical working group within MoE. The group will include a representative from each MoE department and institution with the goal to move gender equality goals from policy to implementation.
- In **Rwanda**, the Rwanda Energy Group's draft Gender Policy (2019) addresses ownership over policy implementation. This includes actions required of GFPs and all senior managers. GFPs report directly to the CEO and are responsible for helping coordinate and facilitate the policy and action plans, as well as monitoring and evaluating their progress. With the Human Resources Management Department, GFPs coordinate staff capacity development, prepare communication and knowledge sharing initiatives, develop tools and guidance notes, and share experiences with other organizations. They also advise and assist senior management and department directors in incorporating gender mainstreaming into their programs. They support the implementation of REG's Policy on Gender Equality and Gender Action Plan (this is also a responsibility of department directors and the ultimate responsibility for the Policy and Plan's implementation rests with senior management). Senior management and department directors are also responsible for ensuring that gender perspectives are incorporated in their work programs and for fostering an enabling environment that prevents discrimination and harassment and supports career development and work-life balance.
- In **Colombia**, the Minister of Mines and Energy is a woman who has been leading the development of the ministry's roadmap toward gender equity. Although the ministry has not yet identified GFPs, the roadmap's focus is on building equity within the ministry's and energy sector's labor forces. Its strategy will likely include a clear articulation of roles and responsibilities for implementing the gender equity policy once formulated.

7.4 STATUS OF IMPLEMENTING GENDER MAINSTREAMING POLICIES AND STRATEGIES

The three countries examined here are at different levels of maturity in implementing gender mainstreaming policies and strategies. All of them have struggled to some degree with implementation. With stronger national mandates for gender mainstreaming, the development of a clear business case showing the benefits of gender diversity in the workplace, and increased international competition and scrutiny, countries are beginning to develop clear, funded action plans to implement gender mainstreaming plans within energy policies broadly and within mini-grid policies and strategies more specifically.

- In **Zambia**, the MoE is conscious of its poor record on policy implementation. Although the Ministry of Gender has produced sector-specific checklists, the MoE has lent them little practical support. The European Union is now supporting the MoE for the production of a practical gender toolkit that identifies entry points to support women's entry into STEM (science, technology, engineering and math) fields throughout the education pipeline, supports women's participation throughout the renewable energy value chain, and addresses practical gender equity needs within the energy sector workforce. For example, the MoE employs many women in their childbearing years who lose many working hours when picking up and dropping off their children at school. It is now proposing an after-school crèche near the MoE. REA has been increasingly involving the community in decisions related to renewable energy projects, mandating sex-balanced community committees that they have created, as a practical starting point to increase the visibility of women in decision-making positions.
- In **Rwanda**, at REG, women still comprise only 18% of all staff. To comply with Rwandan government targets of 30% women's representation at all levels, REG has established a committee to oversee women's representation at all levels of management, equal opportunities in promotions, equal access to career development programs and ability to work in a sexual harassment-free environment.
- Many women encounter social norms and stereotypes that impact their confidence to successfully run an MSME, particularly in male-dominated spaces within the mini-grid value chain. To address this, the Rwandan government has taken concrete actions to establish institutions that support women in advancing their business plans. Women also face stereotypes and lack of trust among male supervisors and counterparts within the mini-grid value chain, which the Rwanda addresses through the provision of 1) capacity building and soft skills training for women, and 2) training for employers to avoid gender stereotypes and make the business case for gender diversity in the workplace. REG's draft sexual harassment policy (2019) also includes a section on implementation, which details specific actions to prevent and respond to sexual harassment within REG. This includes dissemination of information and training with accountability from directors and managers, and specific step-by-step procedures for handling sexual harassment complaints in a survivor-centered approach.
- In **Colombia**, the Ministry of Mines and Energy is taking a methodical, strategic, consultative, and data-based approach to formulating its strategy this year, with the intention that it will provide a foundation for future implementation success via a well-founded business case and buy-in from stakeholders.

7.5 IMPORTANCE OF GENDER-DESCRIPTIVE AND SEX-DISAGGREGATED DATA COLLECTION AND ANALYSIS

Gender-descriptive and sex-disaggregated data has been historically lacking or weak within the energy sector. This has hindered the ability of energy ministries to fully understand gender-based constraints in the mini-grid value chain, leading to an inability to adequately diagnose root causes and propose practical action-oriented solutions through strong gender mainstreaming policies. This is now changing, as more effort is being spent to collect and analyze data that will be the basis for sound gender mainstreaming policy formulation.

- In **Zambia**, the MoE is developing an M&E plan for the entire sector, revamped with gender-responsive indicators. For example, its theory of change calls for

universal access to energy for all; the new M&E plan will disaggregate data collection by sex to identify if "for all" really means so in practice. It is carefully deliberating definitions, such as what "access" means, to ensure the definitions are gender-responsive. Currently, the energy sector as a whole lacks gender descriptive and sex-disaggregated statistics, but with the support of the European Union, the MoE will be surveyed on how its departments have mainstreamed gender. In addition, there are plans to conduct a country-wide baseline survey of 2,500 households in five provinces to understand gender equality issues related to energy access and use. This will be accompanied by community focus group discussions in areas where REA is implementing mini-grid projects to better understand impacts on gender equality and how renewables are addressing women's needs.

- In **Rwanda**, REG recognizes the importance of M&E within its draft gender policy, although clear measurements and targets specific to mini-grids have not been set. The draft sexual harassment policy (2019) contains a provision for the collection of statistics and data to determine the policy's efficacy. The policy requires that the directors and managers responsible for handling sexual harassment cases will report yearly on compliance with this policy, including the number of incidents, how they were resolved, and any recommendations made. As a result of this reporting, REG will then evaluate the effectiveness of this policy and make any changes needed.
- In **Colombia**, the topic of gender mainstreaming specific to the mini-grid value chain is a new one. As a result, the Ministry of Mines and Energy has had difficulties collecting information because it did not have data or baseline assessments. It is now collecting data related to gender equality in rural development, MSMEs and mini-grids. An assessment was also recently supported by the Inter-American Development Bank but has not yet been made public.

PHOTO: USAID Southern Africa Energy Program.

GUIDELINES – GENDER MAINSTREAMING IN MINI-GRID POLICIES, STRATEGIES, AND ACTION PLANS

- Energy policies, strategies, directives and action plans should be updated by policymakers to mainstream gender with concrete actions at the sector level as well as within specific mini-grid policies and strategies, and they should include policy and regulation enforcement tools such as gender parity quotas. This should be informed by a gender analysis or assessment and should be accompanied by a gender mainstreamed monitoring, evaluation and learning (MEL) plan and budget with gender expertise engaged for successful implementation.
- Action plans should be specific, strategic, and practical, and based on sound gender analysis. Two resources can be used to support this: NARUC Practical Guide to Women in Energy Regulation and USAID Energy Equality: the importance of integrating gender equality in national energy policies and frameworks. For example, in Rwanda the strategic focus is on addressing sexual harassment within the REG and meeting the government mandated quota, whereas in Zambia the strategic focus is on strengthening equality within the STEM pipeline and improving opportunities for women across the mini-grid value chain as suppliers and operators rather than reinforcing its role as energy end users. Action plans should be specific, strategic, and practical, and based on sound gender analysis. Two resources can be used to support this: NARUC Practical Guide to Women in Energy Regulation and USAID Energy Equality: the importance of integrating gender equality in national energy policies and frameworks.
- Government policies should require mini-grid developers to conduct project-specific gender analysis and inclusive, equitable community engagement during mini-grid feasibility to ensure developers meaningfully address gender equality in the design, service delivery and workforce of all mini-grid developments, with an emphasis on empowering women to engage in income-generating activities throughout the entire supply chain.
- Increase mini-grid load factors by introducing targeted interventions to empower women to engage more in income-generating activities that involve the productive use of energy.
- Mainstream gender within Ministry of Energy's MEL plan, and specifically for mini-grid policy where one exists with a specific data collection and analysis plan (both quantitative and qualitative) and learning agenda to meet the practical needs of women and improve gender equality across the mini-grid value chain.
- Allocate a budget to the mini-grid policy's gender mainstreaming action plan and MEL plan.
- Identify the human resources needed for the successful implementation of the gender action plan. This may include strategically located GFPs with positions of influence who report to key decision-makers within the ministry of gender. This may also be supplemented by national and international gender and energy experts and/or international and national NGOs with gender and energy expertise.

8. ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI-GRIDS

Photo: © AdobeStock

Although mini-grids are recognized for their light environmental footprint and benefits for community health and safety, they also carry risks that could negatively impact communities and the environment.

Is it essential to consider environmental, health and safety (EHS) risks when determining whether to move forward with mini-grids.

Mini-grids have three types of potential EHS impacts: direct, indirect and cumulative.

8.1 DIRECT ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI-GRIDS

DIRECT ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI-GRIDS

TYPE OF DIRECT IMPACT	DESCRIPTION OF DIRECT IMPACT
Land Use and Land-use Change	Mini-grids directly impact distribution lines, power houses, access roads, etc. and can lead to: • Soil erosion and water pollution from construction • Deforestation that contributes to habitat loss for wildlife and economic loss (such as food sources, pest control, water storage and erosion control) for communities • Wildlife mortality (e.g., with birds and bats) resulting from collisions and electrocutions • Encroachment on protected areas or loss of wildlife habitat and biodiversity
Localized Pollution	Types of pollution caused by mini-grids include: • Air pollution (from fossil fuels and bioenergy) • Water and soil contamination from waste and byproducts (bioenergy, fossil fuels and battery leakage
Battery Waste Management	Depending on the type of battery used in solar and wind systems, there could be hazardous materials, such as lead or cadmium, that need special handling and disposal systems. Battery manufacturers realize the hazardous effects of batteries and have started setting up centers to recycle them.
Water Diversion or Impoundment.	Hydropower facilities that use dams to store river water in reservoirs may alter the flow and location of the water. Water diversion or impoundment can affect people, plants and wildlife that depend on access in certain locations. Changes can also impact water quality and change land uses.
Impacts on Workers and Communities	Electricity by nature is dangerous and can have a direct physical impact on workers and communities during installation if not handled properly. It can have an indirect impact by causing electrical fires, explosion or shock if not properly handled by trained professionals.

8.2 INDIRECT ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI-GRIDS

INDIRECT ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI-GRIDS

TYPE OF INDIRECT IMPACT	DESCRIPTION OF INDIRECT IMPACT
Material Production	Panel production requires the mining of silica and metals, while the solar panel manufacturing process can produce air emissions and toxic waste.
Fuel Source	Biomass-based energy, which involves the combustion of feedstock to generate electricity, has impacts on air quality, water use, land use and life cycle global warming emissions.
End-user Industry	Access to electricity often leads to the development of industrial activity, which may have environmental impacts through increased use of materials and the production of waste streams.
Equity of Access	Access to electricity can create or exacerbate tensions between populations and should be carefully planned, considering existing social dynamics, vulnerabilities and engagement with beneficiaries. Land tenure may be based on traditional use and documentation may be unclear or nonexistent, requiring due diligence at the outset of a project to clarify land ownership.

The cumulative impact of mini-grid construction and development can include:

- Air pollution
- Waste production
- Fuel sourcing
- GHG emissions of power generation and supply chain activities
- Population effects on threatened biodiversity

It is necessary to understand EHS risks and incorporate measures to monitor and mitigate any negative impact.

Several countries require completion of an Environmental and Social Impact Assessment (ESIA) before issuance of a mini-grid license. The below table describes a list of countries and their respective institutions responsible for executing ESIA's for mini-grids.

8.3 MINI-GRIDS ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

MINI-GRIDS ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA)

COUNTRY	RESPONSIBLE ENTITY	RESPONSIBILITY
Tanzania	National Environment Management Council (NEMC)	• Scoping report and terms of reference for full ESIA study submitted to National Environment Council (NEMC) • ESIA study to be approved by Minister of Environment and NEMC • Environmental Management Plan submitted before construction • Environmental Management System for monitoring plant operation and impact • Environmental clearance issued by NEMC
Rwanda	Rwanda Environment Management Authority	Approves the environmental suitability of electricity distribution projects.
Sierra Leone	Environment Protection Agency	Responsible for environmental, social and health impact assessments. Currently developing new guidelines for the assessment of mini-grids.
Indonesia	EBTKE, in co-operation with the Ministry of Environment and Forestry	Compiles environmental guidelines for the management of renewable energy mini-grids.
Uttar Pradesh, India	Ministry of Environment, Forests and Climate Change	In charge of environmental protection and preservation. Assesses the environmental impact of mini-grid projects.
Nigeria	Federal Ministry of Environment	Regulates the implementation of environmental and social impact assessments as a mandatory part of development projects in Nigeria.

GUIDELINES – ENVIRONMENTAL AND SOCIAL IMPACTS OF MINI-GRIDS

- It is important to consider environmental, health and safety (EHS) impacts of mini-grids in project design, implementation and monitoring.
- Risk mitigation measures should be designed to ensure project sustainability and regulatory compliance.
- For developers of small power projects, ESIA's are costly and complex. Therefore, governments should assist developers to fulfill this requirement by providing financial support. Alternatively, governments can undertake ESIAs in one area where the generating source is the same and covers several concessions. Developers can then be included in such ESIAs and not have to incur costs to complete them.
- Mini-grid systems should be built and installed by trained professionals and implemented in accordance with manufacturer requirements and best practices in electrical engineering. End users should be trained in the correct use of the equipment before using it so that they understand its limitations, proper usage and all relevant safety requirements. This is particularly important in areas that have limited experience with electricity.

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APPENDICES